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Semi-Annual Convention of A. R. E. E.

As in years past, the Association of Railway Electrical Engineers will hold its semi-annual convention at Atlantic City during the week of the Master Car Builders and Master Mechanics Conventions. The meeting will be held at the Hotel Dennis at 9:30 A. M. Monday, June 14th. The great display of railroad appliances and shop equipment which involves a large amount of electrical equipment, will make this convention particularly attractive to the electrical men of the railroads.

There will be a number of interesting committee reports presented, among which will be progress reports of the Committee on Metal Conduit Specifications, Committee on Standardization of Crane, Turn Table and Transfer Table Motors, Committee on Wireless Telephone and Telegraph as Applied to Moving Trains, Committee on Power Plant Operation, Committee on Compressed Air Generators, Committee on Standard Rules for Car Wiring, Committee on Standards for Train Lighting Equipment, Committee on Shop Practice, Committee on Electric Head Lights, Committee on Data and Information, Committee on Specifications for Wire Crossing for Potentials Above 100 Volts, Committee on Industrial Trucks, Committee on Reciprocal Relations, Committee on Loose Leaf Binders, Committee on Illumination, Committee on Wire Specifications.

Electricity in Shop and Terminal Operation

It is hardly possible to over estimate the importance of electricity in the operation of modern steam railroad repair shops and terminals. The article on the electrical equipment of the Belt Railway of Chicago, Clearing shops and yards in this issue is an excellent outline of the extensive application of electricity to the many and diversified operations of a huge freight terminal and subsidiary locomotive and car repair shops. The time is not very far for in the past when railroads were content to operate their shop machinery by steam engine and mechanical transmission and install a small generator or purchase electricity for lighting purposes. The modern idea, exemplified by the Clearing installation, calls for the application of electricity to every purpose wherein its use can possibly be justified. To obtain the best result, as in all other things, exact methods, intelligently applied, must be used by the designer of a modern railroad electrical installation. Problems of interior and exterior illumination, requirements of motor drive for shop machinery, hoisting, pumping, compressing air and electrical transmission must be successfully met and treated by long experience in railroad requirements, and a thorough knowledge of modern practice and development in all of the above lines. In other words the up-to-date railway electrical engineer must be more than his title indicates, he must be fully conversant with the important fundamentals of every other branch of engineering practiced on a railroad.

That the designer of these shops has used his railroad experience, coupled with a thorough knowledge of the technical points involved and a thorough understanding of modern practice and apparatus available is apparent from a close inspection of the completed installation, some details of which are illustrated in the photographic reproductions accompanying the article.

The lighting equipment of the locomotive shop, freight yards, wood mill and roundhouse was installed according to data obtained from extensive experiments with various lighting schemes carried out after theoretical results were obtained by calculation. That this extreme care was entirely justified is evidenced by the night photographic reproductions, which show, what are, perhaps, the best examples of railroad shop illumination obtained to date.

The extensive use of alternating current in this plant is indicative of the trend in railroad shop practice. Availability of machine tools with dependable speed changing devices which enable a constant speed motor to be used with results comparing favorably with those obtained from an adjustable speed direct current motor have reduced to a considerable extent the necessity for extensive or exclusive use of direct current power. The use of a synchronous motor generator unit installed primarily for power factor connection and incidentally to obtain a small amount of direct current without expenditure of additional power for the operation of a few tools where adjustment of speed by motor control was particularly desirable, is an arrangement which should be taken advantage of by most railroad electrical engineers in their electrical power work.

A rather extensive use of automatic control for 3-phase motors illustrates strongly the tendency to simplify motor operation and decrease the necessity for attendants at outlying or isolated motor locations.

In general, it may be said safely that the entire plant represents an unusual example of skill in design, execution, attention to details and character of electrical installations, in fact, possesses so many points of interest to the railway electrical engineer that he should not fail to pay it a visit when the opportunity presents itself.

Norfolk & Western Electrification

The electrical section of the Norfolk & Western Railway, known as the Elkhorn Grade, is located on the main line in the southern part of West Virginia, about 105 miles west of Roanoke, and extends from Bluefield to Vivian, a distance of about thirty miles. The section is double track throughout, except in the Elkhorn Tunnel, which is single track. There is also a large amount of third track, or passing sidings, and branches into the coal workings, and yard trackage.

We have reviewed the progress of this electrification from time to time, in the *Railway Electrical Engineer* and in the April number, 1915, on page 335, we published part of a paper which was given by Mr. Gibbs before the Western Society of Engineers in which grade conditions were described and the electrical apparatus discussed. So any points which are omitted from this article can be found by referring to this issue.

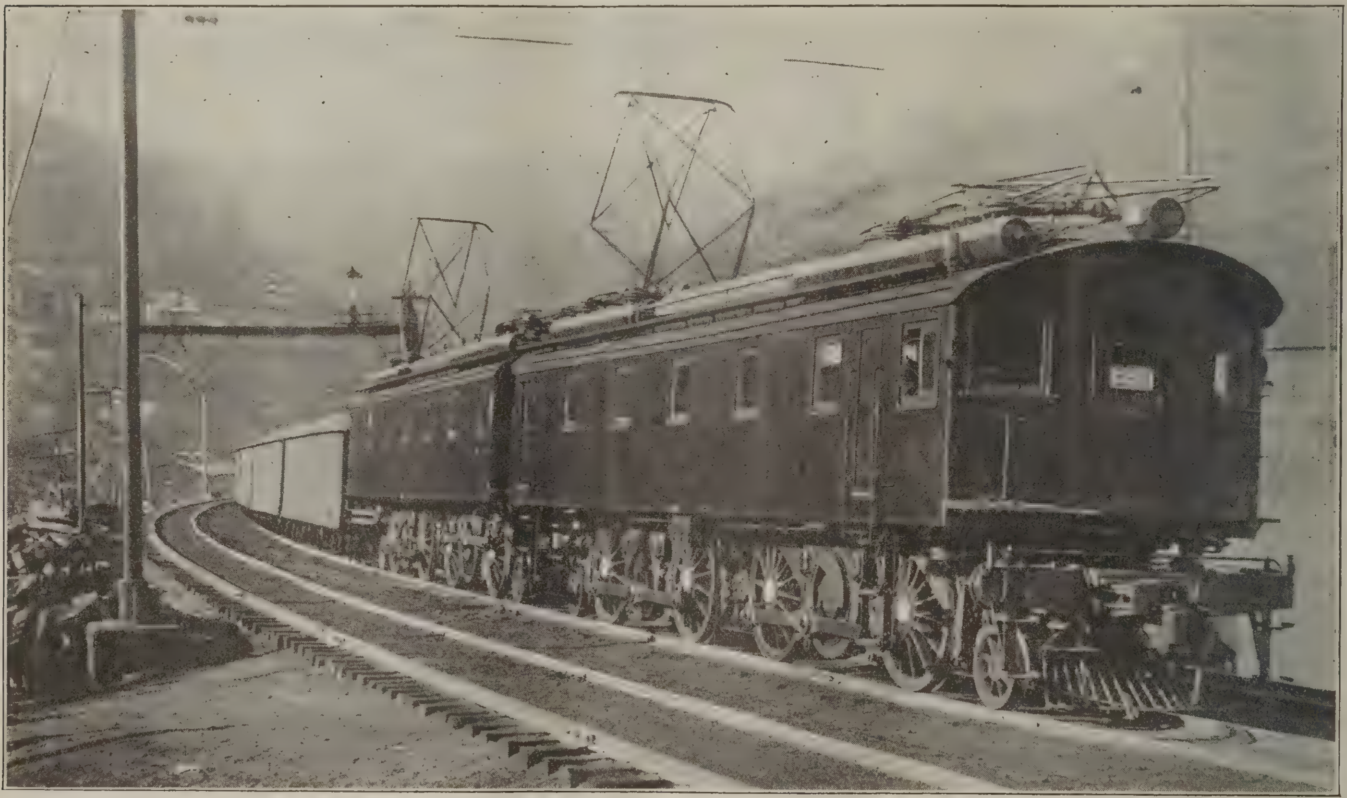

Fig. 1. A Two Unit Locomotive Pulling a Heavy Freight Train on a Steep Grade. These Locomotives Maintain a Uniform Speed Regardless of the Grade.

The grades on the line are heavy, varying from 1.0 per cent, at the west end to 1.5 to 2 per cent. up the grade to and through the summit tunnel, a distance of about ten miles; thence the line descends on a 2.5 per cent. grade for about a mile and then rises again at the ruling rate of about 0.25 per cent. for 10.5 miles and finally up a 1.22 per cent. grade for three miles into Bluefield, the easterly end of the division. Fully 60 per cent. of the line is on curves, the maximum being about 12 degrees.

The electrification of this section of the railway is primarily for the purpose of collecting from the mine sidings and yards in the coal fields the entire eastbound coal tonnage and transporting it up the grades and over the summit to the classification yard at Bluefield, the division point of the railway. From Bluefield, after classification, it is shipped east to the various destination points, chiefly to the Railway company's marine shipping pier at Lamberts Point, near Norfolk, Va. All coal traffic originates west of Flat Top, about six miles east of the summit of the heavy grade, and although a good deal of the coal goes west the easterly shipments are very heavy and this constitutes the chief load handled electrically. Some coal originating east of the summit is shipped to the west and this is also handled by the electric service to yards near the westerly end of the electrified section.

There are numerous colliery sidings throughout the coal fields and the electric service includes the collection of loaded cars or trains from these sidings on the eastbound trip and the delivery of empties on the return trip.

Another condition favorable to electric traction is the fact that trains may be despatched at fairly uniform intervals throughout the day and thus desirable loading conditions on the power system are obtained and at the same time the full service is handled with a moderate number of locomotives, each making a number of round trips per day.

Article prepared from information furnished by Gibbs and Hill, New York, consulting engineers for the railroad.

The purpose of the company in electrifying this section is to increase the capacity of the railway by materially reducing the time required to handle trains and to provide economical and efficient service over the heavy grades. To this end the heavy freight trains are handled with electric locomotives at a running speed up the grades of 14 m.p.h. as compared with about 7½ m.p.h. under steam operation; and a further saving in time is also effected by the elimination of the delays steam trains have heretofore occasioned by occupying the tracks while the engines take on coal and water, one at a time, at the several coal and water stations on the grade. The effect of increased speed is especially marked at the single track Elkhorn Tunnel, 3,000 ft. long on 1.5 per cent. grade, where on account of ventilation requirements, it has been necessary under steam operation to reduce the speed up grade in the tunnel to about six m.p.h. This requires about seven minutes to clear the block, whereas under electric operation this movement is made in about three minutes.

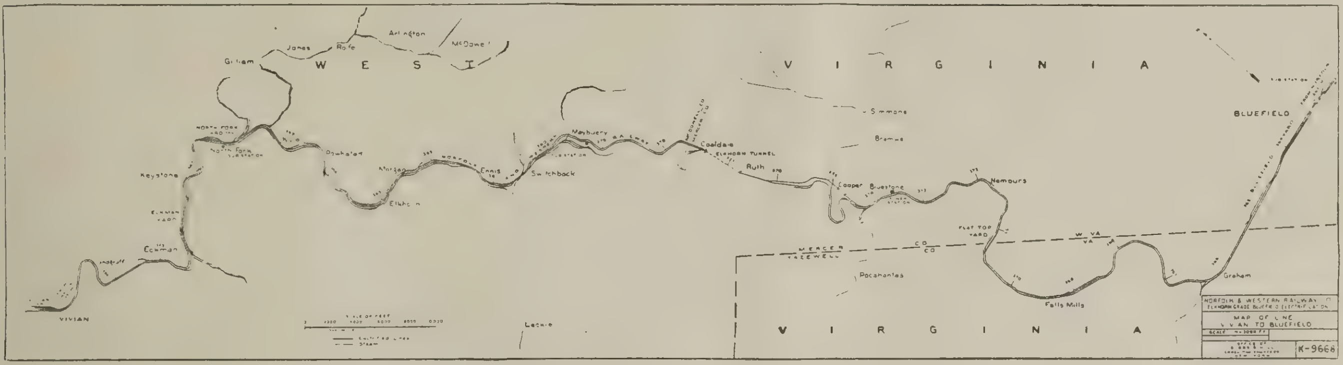

Fig. 2. Map of the Line from Vivian to Bluefield. This Gives a Good Idea of the Number of Curves.

The heavy coal trains, known as "tonnage trains," handled in this service weigh 3,250 tons and have formerly been handled up the grade by three steam locomotives, two of these, a road engine and helper, one at each end of the train, being used over the entire section, and the third, at the rear, serving as a pusher up the 1.5 and 2 per cent. grades, this pusher being cut off at the summit. These steam engines are of the highly developed heavy Mallet type fitted with mechanical stokers and superheaters. Under electric operation a single road engine is used over the division and a second electric engine is used as a pusher up the 1.5 and 2 per cent. grades. Thus it will be seen that one electric engines takes the place of two Mallets over the division or two electric engines take the place of three Mallets up the grades and handle the train at approximately double the steam speed. The speed at which the electric locomotives handle the trains on the 0.4 per cent. grade between Cooper and Graham is 28 m.p.h.

The electrical installation has been laid out and power plant, locomotives and other equipment provided for handling 20 tonnage trains, or 6,500 tons, a day eastbound over the division and ample provisions have been made for additional traffic and extensions when required. The number of these tonnage trains handled per day at present is about twelve, in addition to which pusher and helper service is provided for through freight and passenger trains.

The single phase system of traction is used, power being generated, transmitted and distributed single phase at 25 cycles and collected from the overhead catenary trolley contact system at 11,000 volts. The locomotives, however, are unique in that they are equipped with phase converters, which, in connection with the main step-down transformers on the locomotive, transform the single-phase power of the trolley to three-phase power for use in the three-phase induction type traction motors. Thus, while retaining all the advantages of high voltage single-phase distribution and collection, the advantages of three-phase induction motors for these heavy traction mountain grade conditions are also secured.

Another characteristic feature of the installation is the fact that as the result of the use of traction motors of the polyphase induction type it is feasible without the use of additional or complicated apparatus and devices to utilize the locomotives for electrically holding or braking the trains at constant speed while descending grades. This utilizes the energy in the moving train descending the grade to drive the motors as generators and thus return energy to the line.

This kind of electric braking or "regeneration" has been much discussed and often proposed both in this country and abroad but with the exception of the Giovi line in Italy this feature has not been utilized in any extensive commercial electric railway operation. Even on the Giovi line the train weights do not exceed 400 tons and it is evident, therefore, that this is the first instance where the use of this form of electric braking has ever been attempted for heavy freight train service such as obtains on American railroads.

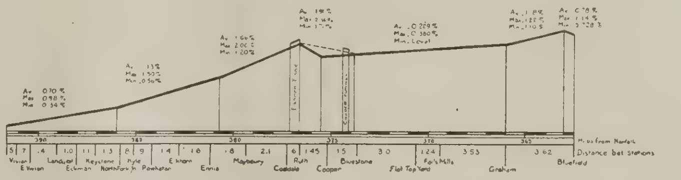

Fig. 3. Diagram of Profile from Vivian to Bluefield.

Catenary Line Construction.

Next to the electric locomotives, the most interesting feature of the electrification is probably the catenary line construction. In designing this feature of the installation, the Engineers had uppermost in mind the two important requirements of reliability of service and low cost of maintenance. An effort has been made to secure the maximum degree of flexibility and freedom from hard spots at the contact wire so as to avoid rapid deterioration and frequent breakages and failures, and a special effort has also been made to provide the highest type of insulation so as to avoid interruptions to service due to insulation break downs.

In designing the supporting structures an effort has been made to secure a neat and attractive appearing structure which would not interfere with the view of signals and which would present the least surface for corrosion and minimize the cost of painting and repairs as well as the first-cost of installation. In working out the design on these lines, the catenary system has taken the form of single catenary with an auxiliary messenger wire above the trolley, one main hanger being provided for every two intermediate connections between auxiliary and trolley on tangents. On curves the angularity of the hangers provided the necessary flexibility, the auxiliary messenger and trolley wire being connected to the hanger at the same point.

The principle of providing more than one single insulator between live parts and ground has been adopted and suspension insulators are used throughout as being the least liable to fail due to transverse stresses. Care has also been taken to guard against failures due to unequal expansion and contraction resulting from temperature changes. For the main line tracks three suspension insulators are connected in series so that the failure of one or even two at any point will not result in the complete breakdown of the insulation and interrupt the service. For the yard tracks and sidings two such insulators are used.

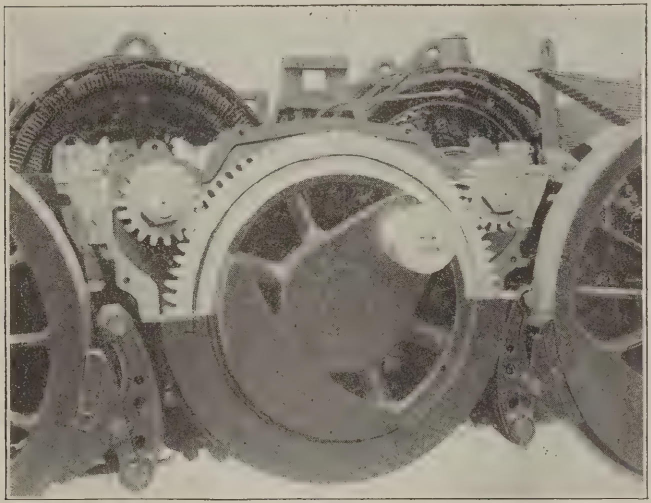

Fig. 4. A Close View of the Locomotive Truck with Body Removed Showing the Connection of the Motors to the Driving Gear.

Great care has been taken also to provide ample clearance between every live part and adjacent grounded structures and as a rule this clearance is maintained at not less than 18 inches so as to avoid the danger of birds or foreign materials causing a short circuit. The same principle applies in the tunnels, the insulators are, however, placed off to the side and out of the direct blast from locomotive stacks and here two 44,000 volt transmission line insulators in series are used in all cases between live points and ground.

In laying out the electrical installation, a great deal of attention has been given to the provision of adequate and convenient facilities for the inspection and maintenance of all parts of the installation. The center and headquarters of the whole system is at Bluestone where the power house is necessarily located on account of the water supply, and after much study it was decided to locate the inspection building and machine shop for maintenance of electric locomotives here also rather than to try to take care of electric engines at the steam engine shops at Bluefield.

In addition to the direct advantages and savings resulting from the electric train service the railway has taken advantage of the presence of an adequate power supply at a net cost of generation for the operation of various auxiliary plants. Thus a large steam pumping station at Bluestone for the water supply for steam locomotives has been shut down and the pumping is done at the electric power station located nearby, and the fans for ventilating the Elkhorn Tunnel will now be driven by electric motors. Likewise electric power will also be ultimately used for operating shops and pumps at Bluefield and several other points on the division.

The electrification of this section had long been under consideration, but the decision to electrify was not reached until about two years ago. The layout and design of the entire installation was worked out in all details by Gibbs & Hill, engineers for the company. All construction, excepting the power house and inspection buildings and some of the power station equipment, was carried out by a specially organized railroad force under the supervision of the engineers.

Power Station.

The power station is of the usual type using steam boilers and steam turbines as the prime movers. It is located at Bluestone, on the Bluestone river, about 11 miles west of Bluefield, mainly for the reason that this is almost the only available source of water for boiler feed and condensing purposes in the district, and the railway company had already constructed a dam and reservoir here for the water supply for its steam locomotives.

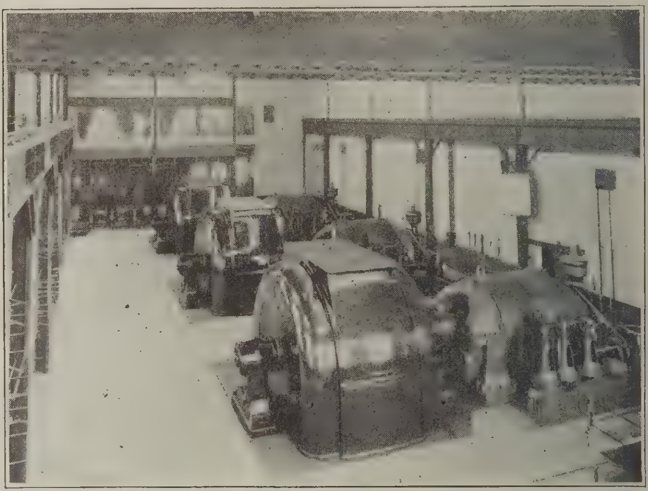

Fig. 5. Power House, Turbine Room, Showing the Main Generating Units. Operating Gallery is on a Level with the Crane Track.

The building is constructed of hard burnt brick; the design is plain and substantial in character. The main structure is about 135 ft. by 158 ft., with a 52 ft. by 33 ft. extension at the northeast corner.

On the ground floor of the extension building or transformer house are the step-up and step-down transformers, and on the second floor is located the high tension switching apparatus.

The main turbo-generator units, exciters and signal generators are located on the main floor of the turbine room, the condenser equipment and fans for cooling the generators being in the basement. The turbine room is spanned by a 30-ton traveling crane.

Coal Handling.

Coal is received in hopper bottom cars on a siding along the south side of the power station. The cars discharge into a 16 ft. by 24 ft. structural steel hopper under the tracks. Below the hopper is a single roll crusher which empties into an inclined conveyor of the continuous bucket type, having a capacity of about 60 tons per hour at a speed of 80 ft. per minute.

The two storage bins are made of 3/8 in. open hearth steel plate and are suspended above and between the boilers from the building girders. Their capacity is about 350 tons. The coal handling machinery is driven by A. C. motors, the crusher motor having a rating of about 35

h. p., the inclined conveyor motor 15 h. p., and the horizontal conveyor motor 10 h. p.

Ash Handling.

A narrow gauge (24 in.) track is located under each row of boiler ash hoppers in the boiler room basement. Steel platform cars, carrying two buckets of one cubic yard capacity each, are pushed along these tracks and loaded by gravity from the ashpit hoppers. They are then run outside the boiler room basement to a loading trolley. This trolley is carried on a steel trestle which spans two siding tracks. It is about 110 ft. long and can accommodate three gondola cars on each track. The buckets are lifted from the small platform cars and emptied into the gondolas by means of a traveling electric hoist. Each hoist can handle a working load of 3,000 lbs. The hoist motors are 220 volt D. C.

Boilers and Stokers.

The boiler plant comprises ten Stirling type water tube boilers, arranged in two rows, with the firing aisle between, each row consisting of two batteries of two boilers each and one single boiler. Space is provided in the present building for four additional boilers.

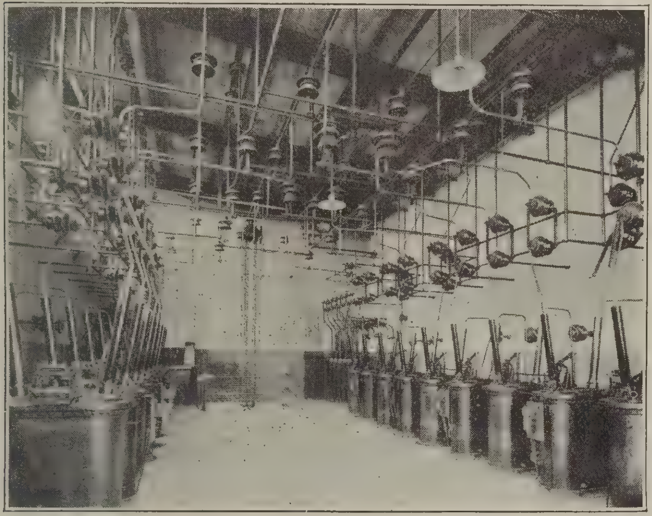

Fig. 6. Interior of High Tension Switching Room in Power House. Note Absence of Brick Partitions or Compartments, Bus-bars Supported from Pipe Framework.

Each boiler is fitted with an underfeed stoker of sufficient capacity to evaporate 61,000 pounds of water per hour into steam at 200 lbs. gauge pressure 150 deg. F. superheat when supplied with feed water at 200 deg. F.

Boiler Feed.

Steam from the exhaust header is discharged into two horizontal Cochrane feed water heaters and purifiers located on the boiler room floor. These are of the cylindrical type, ten feet long and eight feet in diameter, and are arranged to operate as a double unit. Each heater has a total tray surface of 175 square feet, comprised in 80 cast iron trays, each 21 in. by 15 in., and is capable of heating 225,000 pounds of water per hour from 40 deg. to 205 deg. F. The heaters are equipped with oil separators.

Flues and Stack.

The flues are made of sheet iron, lined with asbestos blocks covered with retort cement. Expansion joints are provided in the flues. The stack is of the Custodis radial brick type 268 ft. in height from the base or 250 ft. from the grates, with a minimum inside diameter of 20 ft. A four-inch brick lining extends 75 ft. from the bottom of the flue opening, with a 2-inch air space between the lining and the column. A 24 in. by 36 in. cleanout door is provided about 14 ft. above the ground, opposite the flue opening.

Draft.

The forced draft installation in the boiler room basement consists of three Sturtevant multivane turbine driven fans. These are of the manufacturer's No. 12, seven-eighths housed type with double inlets and upward discharge. The fan wheels are 58¼ in. in diameter, each having 48 curved steel blades 60 in. wide. The casing is of sheet steel suitably stiffened and braced to prevent vibration.

The fans are driven by steam turbines through a 4:1 herringbone reduction gearing. These turbines are of the standard Sturtevant E-5 type and have a normal rating of about 300 h.p. each. The rated capacity of each fan is 150,000 cu. ft. of free air per minute against a static pressure of 6 inches of water when running at 540 r.p.m.

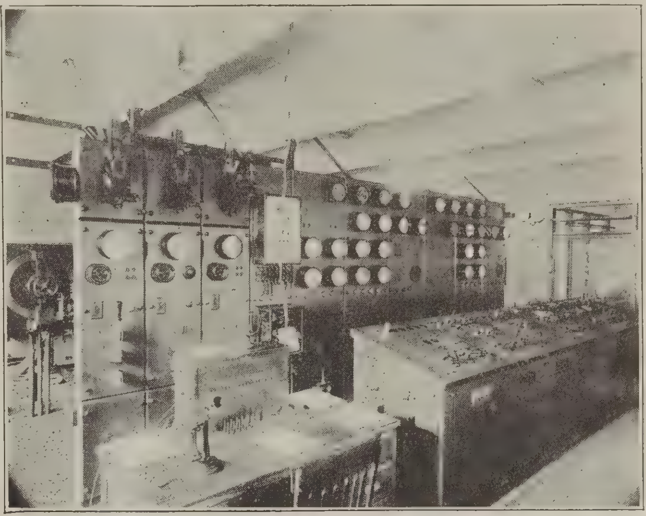

Fig. 7. Control Boards in the Operating Gallery.

Steam Turbines.

The initial equipment consists of three main generating units, with space provided for a fourth. These units are horizontal turbines of the Westinghouse-Parsons impulse reaction double flow type rated at 10,000 kw. with steam at 190 lbs., superheated 150 deg. F. and 28½ in. vacuum when running at 1500 r.p.m.

A simple speed limit governor trips the automatic stop valve whenever the speed of the turbine exceeds a predetermined value.

Each turbine is equipped with a separate condenser of the Le Blanc Jet type, connected directly to the discharge flanges of the turbine. The injection water is taken from the intake tunnel which runs under the basement floor. The condenser injection water and air pumps are driven by a horizontal turbine. The air pump discharges into an intake canal and the ejection pump discharges into a pipe leading to a spray cooling pond.

Generators.

The main turbo-generators are of the Westinghouse type, having a rating of 10,000 kw. at 80 per cent. power factor, 11,0000 volts, 25 cycles, single phase. At this rating, the generators are specified to operate for twenty-four hours with a rise in temperature not exceeding 60 deg. centigrade above the temperature of the cooling air. This temperature rating is used because the load factor and form of the load curve is such that a rating on this basis gives a truer conception of the size of the plant required for the service than would be obtained by adhering to the usual temperature basis of rating machines operating on a high load factor. They are capable of delivering a single phase output of 12,500 kw. at 80 per cent. power factor for 5 minutes without injurious heating.

Switching Apparatus.

The main 11,000 volt bus is sectionalized and 3-phase power for auxiliary purposes is taken from the island section. No brick of concrete bus compartments are used, the bus being of copper tubing carried on insulators mounted on pipe framework. Copper tubing and bare wire is used wherever possible; insulated wire being used only where conductors are carried in conduits.

The power supply to the 11,000-volt side of the three 5,000 K. V. A. step-up transformers is controlled by three 2-pole oil circuit breakers. The oil circuit breakers on the 11,000-volt circuits are solenoid operated and are mounted on pipe framework. The leads from the oil circuit breakers are insulated and run in conduits and on insulators to the transformers located on the lower floor of the transformer house.

All switching apparatus is controlled from the operating gallery. The switchboards consist of a generator bench, main power board, auxiliary power board, and a signal power board.

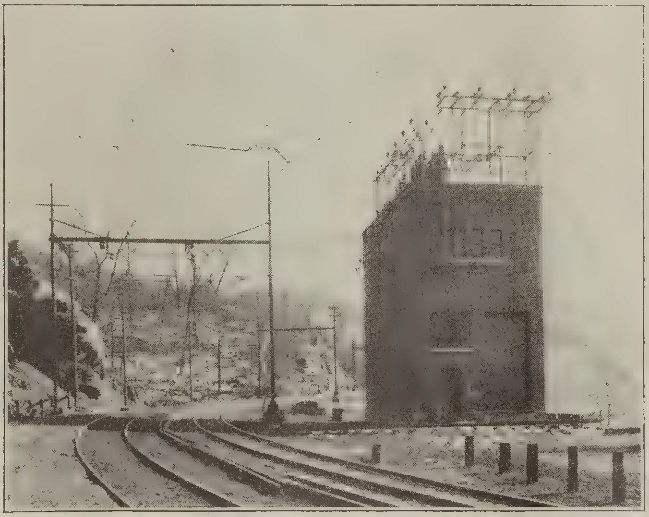

Fig. 8. Exterior of Maybeury Substation. This is a Typical Substation.

Regeneration Loading Rheostats.

Excess regenerated power returned to the power house at no load passes to the 11,000-volt bus and through the various transformers back to the generators if the generators are running under very light load or no load. If no other load were provided, the regenerated power would reverse the generators and operate them as motors. To prevent this a loading device consisting of electrodes immersed in the intake canal and controlled by suitable switches is provided. The operation of the switches is made automatic by means of a group of relays and magnetic switches, current transformers, etc., so connected as to give the following results.

Each rheostat consists of a steel cone carrying a lead from the circuit breakers, and a fixed ingot iron plate located at the bottom of the intake canal, and grounded to a copper plate bedded in the earth outside of the canal. The power dissipating capacity is adjusted by varying the distance between the cone and the iron plate.

Transmission.

High tension power is transmitted at 44,000 volts, 25 cycles, single phase. The wires are carried on the catenary supports, except at the tunnels, where the line goes above ground over the summits. The method of support is clearly shown in Figs. 8 and 10.

As can be seen in the illustrations, there are two single phase lines. These consist of four No. 2/0-seven strand hard drawn copper wires. A 3/8-in. steel ground wire is carried on the poles for the length of the line. The high tension insulators are of the four petticoat pin type with a maximum diameter of 12 in., and are tested at 165,000 and 120,000 volts respectively, for dry and wet flashover.

Substations.

All power supplied to the trolley system and trains is obtained from transformers which step down the voltage from 44,000 to 11,000 volts. These are located at suitable points along the line and are housed in suitable buildings except at West Vivian, where the apparatus is of the outdoor type and unhoused.

The oil circuit breakers in the substations are remote-controlled and will be operated from adjacent signal towers or passenger stations, or yard master's offices, thus requiring no attendance. Power at 440 volts for the operation of oil circuit breakers is obtained from two step-down transformers, one connected to the 11,000-volt bus and one to the 44,000-volt bus.

The equipment of substations is as follows:

Bluefield	2—3,000 K.V.A. Units	6,000 K.V.A.
Bluestone (Power House)	2—2,000 K.V.A. Units	4,000 K.V.A.
Maybeury	2—5,000 K.V.A. Units	10,000 K.V.A.
North Fork	2—3,000 K.V.A. Units	6,000 K.V.A.
Vivian	1—2,000 K.V.A. Unit	2,000 K.V.A.
Total capacity		28,000 K.V.A.

Distribution and Catenary Construction.

One advantage of using a very high voltage on the contact system is that no supplementary feeders are required, the distribution of power from substations being effected entirely by means of the trolley lines proper. Supporting structures.

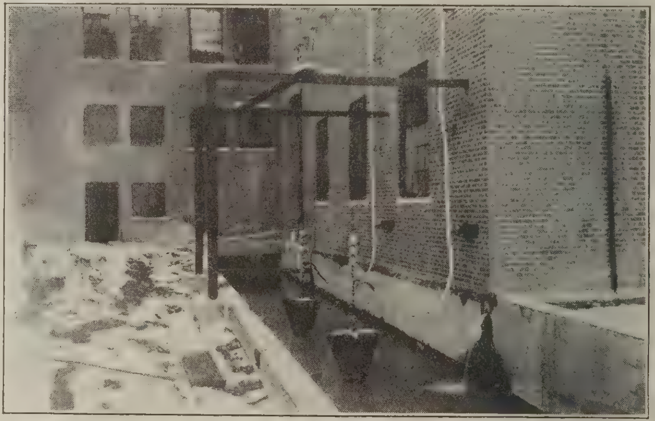

Fig. 9. Regenerated Power Loading Rheostats in the Intake Canal Outside of the Power House Substation. Note Provision for Raising and Lowering the Cones in the Water.

There are two distinct types of structures used for supporting the system of catenary or trolley lines; one, which is used on the main line, where the wires are suspended from overhead beams or girders and the other, used in yards, where an overhead cross-catenary cable is used to support the longitudinal catenary wires of a large number of tracks.

The structure as a whole is unguyed if on tangent track, but on curved track is guyed on the outside of the curve, that is, guyed against the curve pull of the catenary system.

Catenary supporting structures are nominally 300 ft.

apart on tangent track and somewhat closer together on curves depending on the degree of curvature and whether or not intermediate pulloff poles are used between adjacent supporting structures.

The foundations are of 1:2:5 concrete, reinforced with rods, and cored with a collapsible form. A copper ground plate being set in coke underneath one of the two foundations and a substantial copper cable carried up through the concrete for later attachment to the pole with an expanded pin type bond terminal.

The Catenary System.

The appearance of the catenary system is so simple that one has to actually build it before appreciating the many problems and difficulties that surround its design and construction.

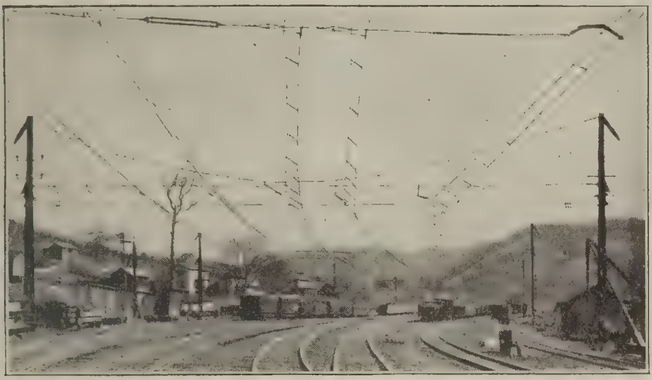

Fig. 10. Cross Catenary Construction Used in the Yards. Notice the Small Amount of Obstruction Offered by This Type of Construction.

Over tangent tracks the construction is simple. From each of the supporting structures a steel casting attached to the horizontal beam or girder serves as a support for three suspension type insulators. Each of these three insulators is of itself good for a working voltage of 11,000 volts and three are used as a special insurance against line troubles. These porcelain insulators are 8 in. in diameter, a little over 5 in. long and have an ultimate strength of 12,000 pounds. Since the initial energizing of the line about the middle of December, there has not been a single failure of any of these strings of insulators.

The messenger wire is ½-in. extra high tension galvanized steel stranded cable having a breaking value of over 30,000 pounds. Spaced 30 ft. apart along the messenger wire are bent strap clips which hold the hanger straps. These rectangular hanger straps are of galvanized steel and they are all of different lengths depending on their distance from the low point of the messenger wire, the length of each hanger being calculated so that the bottom of all hangers will be the same distance above top of rail.

All calculations are made for an average temperature of 60 deg. As the temperature lowers, the tension in all wires increases and the contact wire rises somewhat in the center of the span, but even a 6-in. rise in a 300-ft. span makes a trolley gradient of only 1/12 of one per cent., whereas gradients of ½ of one per cent. are permissible. As the temperature rises above 60 deg. all tensions decrease and the contact wire sags uniformly toward the center of the span with a maximum sag of a few inches.

Where the track is curved, as it is in the larger portion of the work, the trolley or contact wire must also be curved so that it approximates the track curvature. The system has been designed within limits such that the contact wire may be 12 in. off the center line of track in one direction at the bridges or points of support and 6 in. off the center line of track in the other direction at the center of the span. This allows the trolley curvature to be less than the track curvature, the middle ordinate of the trolley curve in a given span being 18 in. less than the middle ordinate of the track curve provided full advantage has been taken of the permissable limits of trolley departure.

On curved track the catenary system, that is, messenger wire, hangers and trolley wires, instead of lying in a vertical plane as over tangent track lies in an inclined plane which is warped until the trolley curvature approaches the track curvature.

The suspension insulators instead of hanging vertically respond to the curve pull of the system and hang at a definite angle depending upon the curvature of the system.

In the Elkhorn tunnel special catenary construction was necessary. This is a single track tunnel, 3,000 ft. long, the walls are 14 ft. apart at the spring line and 13 ft. apart at the base, the spring line is 11 ft. 1 in. above top of rails, while the top of the arch is 19 ft. 3 in. high. Extended experiments in insulators and arrangement of same were made in a sample metal-lined tunnel where high voltages were submitted to the smoke and steam from a locomotive. The arrangement adopted was to have a supporting structure every 75 ft. apart. At each side of each structure two cast iron brackets held to the brick lining of the tunnel by large bronze expansion bolts; each carry a 44,000-volt transmission line insulator. A 2-in. brass pipe is carried parallel to the tracks by the pair of insulators on each side. Another line insulator on each side is mounted by bronze castings at the middle of these pipes and a cross pipe bent to follow the arch of the tunnel forms the support for a bronze messenger wire. The live catenary parts have, therefore, double 44,000-volt insulation to ground. Despite the necessarily very limited clearances, the work in this tunnel stood a test of three times normal trolley voltage and has so far performed very satisfactorily for the several weeks it has been in service.

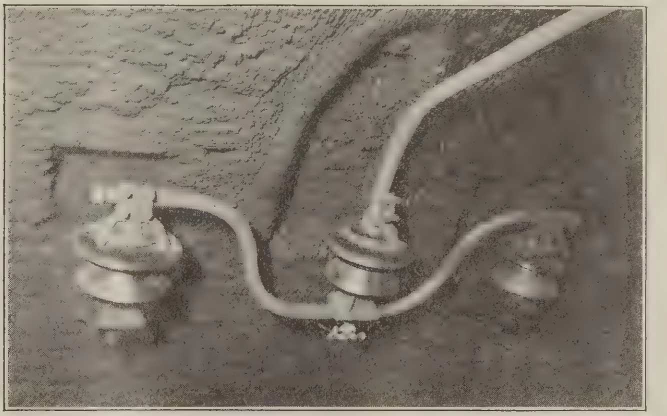

Fig. 11. Close View of One Side of Catenary Bracket in Elkhorn Tunnel. Note the Recess Back of Insulators to Provide the Proper Clearance.

Track Bonds.

At signal bridges the rail joints are insulated and it is necessary to install bonds so that the flow of propulsion current shall be continuous. This result is accomplished by the use of impedance bonds which prevent the flow of 60-cycle signal current from getting past the insulated joint but still does not interfere with the flow of 25-cycle propulsion current.

Protection of Telephone and Telegraph Lines.

In order to protect the telephone and telegraph lines along the railway from danger of interruption of the service due to the electrical installation, it was necessary to make certain provisions; first, against the hazard of physical contact between falling telegraph wires and high tension power wires, and, second, against induction set up in parallel telephone and telegraph lines due to current flowing in the power circuits.

To provide against induction it was decided to place the main transformer substations somewhat closer together than would be required by considerations of voltage regulations and losses and to place the end substations near the ends of the line. This results in feeding each important or long section of trolley from both ends and thus current fed to the trains in the section between substations flows in both directions in the trolley and track circuits and consequently the induced voltage in parallel telephones and telegraph lines is largely localized and neutralized. In addition to this, however, in order to provide for emergency conditions when one substation may be out of service and for excessively high currents which occur in cases of short circuits and grounds, it was decided to install so-called track transformers or boosters in the trolley and track circuit at intervals of about one mile.

Locomotives.

The traffic on the electrified section is handled by twelve 270-ton Baldwin-Westinghouse locomotives, each consisting of two 125-ton units or halves.

It is necessary in handling heavy trains on mountain grades to have a part of the motive power at the rear of the train in order to avoid excessive strains on the draft rigging of the cars. In this case the power is divided equally between the two ends of the train and the trains are of such great length in this mountainous country that there is difficulty of signaling from one locomotive to the other and thus the locomotives are subject to treatment which would be considered impossible in ordinary service. In meeting these conditions the rugged construction of the three phase induction motor being free from commutators and the liquid rheostat are of the greatest importance. The liquid rheostat not only gives the smoothest possible gradations of tractive effort, but the latent heat of steam makes it possible without difficulty to dissipate the large amount of heat generated in the rheostat in meeting these service requirements.

The inherent characteristics of the induction motor which enable the locomotive to automatically hold the train at a constant speed on descending grades by regenerating and returning power to the line, also accentuate the advantages of this type of locomotive.

Each locomotive is equipped with eight traction motors of the three-phase induction type, with wound secondaries for four pole and eight pole operation. The motors are forced cooled by air from the main ventilating duct, which also delivers air to the phase converter and to cooling towers for the liquid rheostats.

There are two running speeds, 14 and 28 miles per hour. In starting, resistance is inserted in the secondary circuit of the motor by means of a liquid rheostat. For the 14 mph. speed all motors are connected in parallel, having the eight pole motor combination and for the 28 mph. speed they are also connected in parallel but with the four pole motor combination.

The locomotives are equipped with unit switch type of control and arranged for the simultaneous operation of the two units from the control end of either.

The control equipment is built for handling alternating current, which is collected from the 11,000-volt line by the pantagraph trolleys. This current is fed to the main transformers through an oil type circuit breaker. A phase converter is connected to the low tension side of the transformer and operates constantly when the locomotive is in service. To its extended shaft are coupled a blower for cooling the motors, transformers and other parts, and, through a clutch the air compressor. The converter is an induction motor with a short circuited or cage wound secondary having two windings on its stator, one to drive the rotor and the other to furnish current out of phase with the main supply current.

The motor circuit of the primary winding of this converter is connected across the secondary of the locomotive transformer and receives current at 725 volts. The arrangement of windings is such that with the converter running, a current of 90 deg. phase displacement is induced in the second winding on the primary of the converter. By connecting this displacement circuit to the middle tap of the main transformer, a three phase current is produced by the ordinary two-phase three-phase method of connection. It is only necessary to convert a portion of the current used in the main motors as a large portion comes directly from the main transformers.

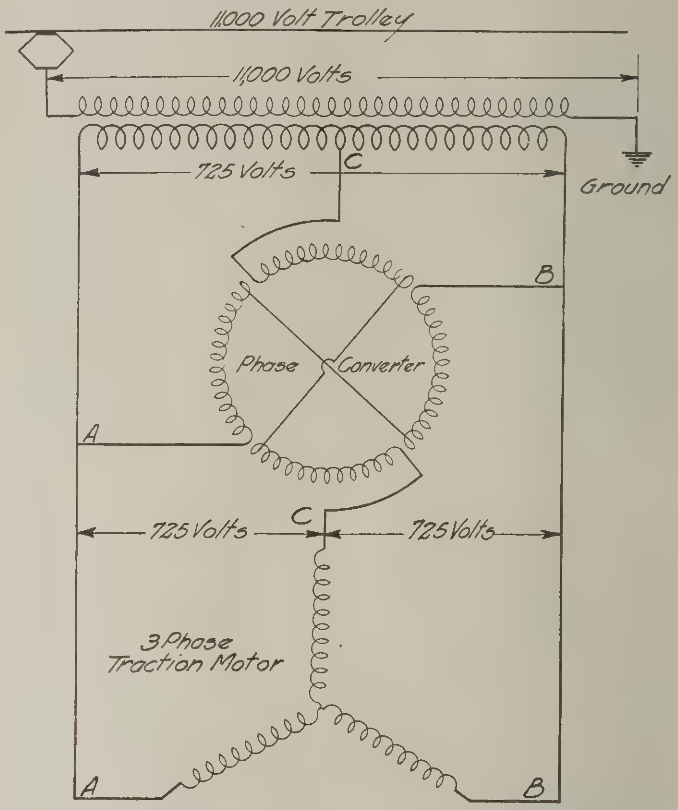

Fig. 12. Diagrammatic Sketch of the Phase Converter. Showing How Single Phase Current is Used to Operate Three Phase Motors.

For starting the converter a single-phase series commutator type motor is mounted directly on the shaft of the converter.

The phase converter is forced ventilated, having a connection at its center to the main ventilating air duct of the unit.

Two trolleys are mounted on the roof of each unit; they are of the well known pantagraph type, but are unique in that they have been arranged so that if necessary they may be fitted with end horns which will automatically fold in when the pantagraph is lowered by the tunnel trolley wire.

On each unit there are four liquid rheostats, one for each motor. The rheostats are operated in pairs, each pair having in common, one storage reservoir and cooling tower, one circulating pump and one operating mechanism. The liquid rheostats provide the motor circuit resistance required in order that the speed of the motors may be slow at starting and may be gradually increased as the resistance is cut out of circuit.

The essential elements of each rheostat are a cast iron tank in which are mounted electrodes consisting of certain metal plates connected to the motor and another set of such plates adjacent thereto and connected to ground; a hollow plunger, located at the center of the tank for regulating the height of the liquid and which is raised or lowered by an operating mechanism; and a motor-driven centrifugal circulating pump by which the liquid is continuously circulated to prevent excessive heating, the liquid being forced up through the bottom of the tank and over the top of the hollow plunger when the plunger is raised and back through the inside of the plunger to the storage reservoir.

A rheostat similar to this made by the Italian Westinghouse Company was described in the March number of the RAILWAY ELECTRICAL ENGINEER in connection with the electrification of the Italian State Railways.

To keep the temperature of the circulating liquid as low as possible, a portion is bypassed through a cooling tower containing a series of trays so arranged that the liquid will flow over them in a thin sheet and be cooled by air from the main ventilating duct to which the towers are connected.

For the purpose of cooling the various pieces of apparatus, there is a 36-in. Sirocco fan mounted on the shaft of the phase converter, and arranged to deliver the air to a duct built into the cab floor under the deck. The duct runs lengthwise through the cab and is arranged with openings at various points where connections are made to the traction motors, phase converters, cooling towers, etc.

The electrical equipment has been designed to provide for electric braking on grades by regeneration, both for the purpose of safety and economy of operation. These features bring about a decrease in the wear and tear on the brake equipment and a reduction on the demand on the power system, provided, of course, regeneration takes place at the same time that power is required for other purposes.

The following tables show the principal dimensions and weight of each complete locomotive:

	Ft.	In.
Length overall	105	8
Driving wheel base, total	83	10
Rigid wheel base	11	0
Truck wheel base	16	6
Height, rail to pantagraph (locked)	16	0
Height, rail to top of cab (maximum)	14	9
Width overall (maximum)	11	6¼
Width over cab body	10	3
Diameter of driving wheels		62
Diameter of pony wheels		30
Weight on drivers		220 tons
Total weight of locomotive		270 tons

The following tables show the performance of these locomotives under varying conditions of load:

	Train on 1.5 and 2 per cent. grades	Train on 1 per cent. grades	Train on 0.4 per cent grades
Weight of train, tons	3,250	3,250	3,250
Locomotives per train	2	1	1
Approximate speed, miles per hour	14	14	28
Drawbar pull per locomotive, pounds			
Uniform acceleration	91,800	114,000	79,400
At speed on 2 per cent. grade	75,400	-------	-------
At speed on 1 per cent. grade	-------	85,800	-------
At speed on 0.4 per cent. grade	-------	-------	4,600
Maximum guaranteed accelerating tractive effort per locomotive	133,000	133,000	90,000
Approximate maximum guaranteed H. P. developed by motors	5,000	5,000	6,700

On tests and in service the locomotives have developed a drawbar pull considerably in excess of the guaranteed maximum. The highest record with the dynamometer car being 180,000 pounds. This corresponds to an adhesion of about 40 per cent.

Electric Car Lighting

By E. S. McNab

Inspector of Electric Car Lighting, Canadian Pacific Railway.

The problem of lighting passenger equipment by electricity is comparatively new on this continent, although in Europe and the British Isles it has been the practice for about twenty-five years. However, the rapid increase in the number of equipments applied in North America, during the last few years, has to a great extent compensated for the relatively late start.

A perusal of Fig. 1 will show the number of electric-lighted cars in service in the United States and Canada in 1911 and 1914 respectively. It is noticeable that in 1911 the Canadian Pacific Railway had only 68 electric lighted cars, whereas this figure has now been increased to 380, which includes 100% of the compartment sleepers and observation cars, 85% of the modern sleepers and 60% of the total numbers of diners, the remaining gas lighted cars of these classes are being converted as the cars receive general repairs. The large increases on the Pennsylvania, New York Central and Hudson River, and N. Y., N. H. & H. Railways are probably due to the tunnels by which they enter New York City, gas or oil lighted cars not being permitted to enter either of these terminals. From the foregoing figures it is apparent that there is a strong demand for electric lighting in our passenger cars, and also that the railway companies are meeting it in a liberal spirit.

Table Showing Increase in Electrically Lighted Cars, 1911 to 1914.

Railway Company	Number of Cars Equipped 1911	Number of Cars Equipped 1914	Increase in Cars Equipped
Pullman Company	2,400	5,800	3,400
Pennsylvania R. R., E.	902	1,924	1,022
Pennsylvania R. R., W.	516	714	198
N. Y. C. & H. R.	202	1,007	855
N. Y., N. H. & H.	350	410	50
Lehigh Valley	81	384	303
Great Northern	480	650	190
Total in United States	10,925	18,572	7,647
Canadian Pacific Ry.	68	359	291
Grand Trunk	34	164	130
Grand Trunk Pacific	..	72	72
Canadian Northern	14	226	212
Total in Canada	116	821	705

Note: Figures of other roads not included.

I will next endeavor to explain the methods adopted in lighting cars by electricity, and I will divide them in three main systems, namely, Straight Storage System, Head End System, and Axle System, and a brief description of each may not be out of place.

Straight Storage System.

This equipment consists of a set of storage batteries contained in battery boxes under each car, the batteries being connected to the lamps by the usual wires and controlled by a single switch or switches. This is certainly the simplest method of lighting, but when we investigate its methods of operation we begin to get into difficulties.

In the first instance, the batteries have to be charged at each terminal, or at least after every eighteen to twenty-four hours of lighting, which necessitates the car being held in the terminal yard for a period of from six to ten hours, depending on the condition of the batteries on arrival.

It is interesting to note that at one of the New York yards 350 outlets have been installed, each outlet having a separate pair of wires back to the switchboard in the power house, No. 8 cable being the smallest size used. Power is obtained from three 250-k. w. motor-generator sets, giving 110 and 220 volts. The switchboard arrangement is also considerably complicated due to the large number of individual circuits which have to be controlled.

It is interesting to note in passing that an attempt has been made to reduce the lengthy period of charge by increasing the charging rate by the use of the Wilson battery. This battery is so constructed that it can be charged at 1,000 amp. rate for a short period, but as is apparent, this high rate involves specially heavy charging cables throughout the yards, and also special fittings on the cars. It has been adopted to a limited extent on the Erie railroad on its suburban trains, but its non-adoption by any of the other roads indicates that its disadvantages overbalance its advantages.

Head End System.

This system as its name implies consists of a steam driven generator in the baggage car, located as close to the locomotive as possible. This system is in use on most of the roads running west of Chicago, and on "Limited" or solid trains, gives good service. The equipment consists of a 20 or 25 k. w. turbo-generator located in the baggage-car, driven by steam from the locomotive, a control switchboard is installed from which three main cables run overhead throughout the trains. As the turbine must necessarily be stopped during change of engines or while standing in a terminal before the locomotive is coupled up, it is therefore necessary to install a certain number of storage batteries on the train which will carry the lighting load during the above-mentioned periods.

It is the Northern Pacific practice to install 200 amp.-hour batteries on the postal car, dynamo car, standard sleepers, and observation car on each train. On most of the roads using this system the baggagemen are trained to operate the electrical equipment and after showing a certain proficiency by means of examinations, receive higher pay. I am advised by several of the electrical engineers that these men are giving satisfaction; some roads, however, still continue to employ train electricians.

The chief disadvantage of this system is the want of flexibility and this is felt where trains have to be remarshalled at junctions and cars switched off on branch lines; this leads to the necessity of equipping a large proportion of the cars on every train with batteries, increasing the capital and maintenance costs. Another disadvantage is the high steam consumption which the turbine accounts for, and our experience in Canada points to considerable difficulties from this source during the winter months should this system ever be tried.

Axle Generator Systems.

This comprises a generator driven by means of a belt from the axle and a set of storage batteries which supply current to the lamps when the train is at rest. As this equipment is applied to each car it follows that it is an individual unit and can be transferred to any line in any class of service without any adjustment of the apparatus being necessary.

In describing the methods of operation of the various patent systems used, I will begin by pointing out that the design of an axle device involves the overcoming of five problems; (1) The reversal of polarity, due to the change in direction of rotation of the armature, when the car reverses the direction in which it runs; (2) The maintenance of a constant output in watts or horsepower, irrespective of the speed of the train, after the generator reaches its maximum, which is twenty-two to twenty-five miles per hour; (3) The lamp voltage must be held constant at the normal voltage which is thirty in the United States, and generally twenty-four in Canada, while the generator is running at a voltage of forty in the United States and thirty in Canada; (4) The batteries must receive a sufficient charge to replenish the loss of current consumed at terminal stops, but at the same time must not overcharge them; (5) An automatic arrangement must connect the generator to the batteries when the speed of the train is such that the generator voltage is equal to the battery voltage, and disconnect them when the speed falls below that point. To meet the foregoing conditions there are about a dozen patent systems in use in Europe, none of these have ever been adopted in this country, with the exception of the Stone System, which is extensively used in Canada. In the United States there are five principal systems, namely, the "Safety," "Gould," "Consolidated," "United States," and the "E. S. B.". I will give a short description of the operation of each but I will refrain from making any criticisms as to their advantages or disadvantages, as it is not my intention to boost or criticise any of the systems, all of which have their good and weak points.

The Stone System.

As the Stone System is more in evidence in Canada, I will begin with it.

1. Change of Polarity: This is effected by means of a rocking arm which is turned through an angle of about thirty degress by a friction gear attached to the end of the armature shaft.

2. Constant output is maintained by means of suspending the generator out of centre and by means of a tension screw in the suspension, so that it is possible to vary the tension of the belt to give the desired watt output. This method of regulation appears at first sight to be rather crude, but it is surprising how well it acts in actual practice.

3. Lamp Voltage Control is obtained by the use of two batteries, one being charged while the other "floats" across the lamps. The floating battery and lamps are supplied with current from the generator through fixed resistances in multiple, which are connected so that when certain circuits are switched on, a resistance is also switched in multiple with the others; by this means it is possible to obtain close regulation with a varying lamp load.

4. Battery Overcharge: By means of specific gravity tests of the batteries, it is impossible to regulate the

tension of the belt so that the total output on the trip will take care of the lamp consumption and at the same time keep the batteries fully charged. A battery change-over switch is also used to reverse the charging and regulating battery at each stop.

5. Automatic Switch: This is operated by means of a governor attached to the end of the armature shaft, in conjunction with the friction gear and rocking arm mentioned above, operating a switch, which closes when the generator voltage equals that of the battery. The keynote of this system is simplicity, all the moving parts being contained in the dynamo, and can be readily changed if necessary. The switchboard contains only the main and circuit switches, also branch fuses. It is therefore impossible for the train crew to cause any damage to the equipment through carelessness or otherwise.

The "Safety" and "Gould" Systems.

I will treat the Safety and Gould equipments together, as they have many points in common.

1. Change of Polarity: This is effected in the Safety system by means of rocking the brush holder through an angle of ninety degrees by means of the friction between the brushes and the commutator. In the Gould system a double-throw switch is operated by means of a "dog" attached to the end of the armature shaft engaging a cam when the direction of the rotation is changed.

2. In both systems the voltage of the generator is held constant by a voltage coil connected across the brushes, this coil operating a solenoid which, by means of a lever, reduces the pressure in a carbon pile in series with the "field."

3. Lamp Voltage Control is obtained by inserting a carbon pile in the lamp circuit, the pressure of the discs being regulated by means of a solenoid connected across the lamp mains. As the voltage increases the solenoid operates and reduces the pressure on the pile, increasing the resistance in the circuit. In the Gould system a pilot or small carbon pile is introduced to operate the large carbon pile with the object of giving finer adjustment in the system; the main pile is short-circuited when the car is at rest, and allows the battery to feed the lamps direct.

4. Battery Overcharge: In both systems the voltage of the generator being maintained constant, as the battery becomes charged, its voltage rises until it is practically equal to that of the generator when the charge is reduced to about three amperes. A series coil introduced in conjunction with the voltage coil of the generator regulator, operates the carbon pile in the field, preventing the output exceeding a predetermined amperage which would occur in the case of the generator becoming connected to a discharged battery.

5. Automatic Switch: Is electrically operated, a voltage coil being connected across the brushes which lifts a switch when the generator voltage reaches that of the battery.

Both systems have been applied to a large number of cars in the United States.

The "U. S. L." System

The United States lighting system provides for the change in polarity of the generator by rocking the brush holders through an angle of ninety degrees. The generator regulation is controlled by a carbon pile in series with the field, which is operated by means of a solenoid composed of a series and shunt-winding. The lamp regulation is also taken care of by a carbon pile in series with the lamp circuit, which is operated by a shunt coil connected across the lamp mains.

The chief feature of interest in this system is the control of the battery charge by means of the ampere hour meter. The meter is located in series with the batteries and when they are being discharged the indicating hand travels over a circular dial in clockwise direction and during charge in a reverse direction. The scale reading from 0 to 400, the position of the pointer indicates at any moment the amount of discharge, zero being the full-charge mark. When the hand of the meter travels back to zero, which shows full charge, it operates a small switch, which, by means of a relay, reduces the generator voltage to the lamp voltage, from 40 to 30 volts, cutting down the charge to the batteries. The meter is so constructed that it reads 20% slower on charge than discharge, which accounts for the necessary excess of charge over discharge required. The Pullman Co. have applied this arrangement to several hundred cars and I am advised that so far the results have been satisfactory.

The "Consolidated" System.

The later Consolidated equipments have a similar arrangement embodying the use of the ampere hour meter, and with this equipment metal resistance grids are used in the field of the generator and lamp regulator instead of a carbon pile. A worm gear operated by the armature shaft in conjunction with a double-pole two-way switch effects the change in the polarity.

The "E. S. B." System.

The E. S. B. system presents several features of interest, using the Rosenberg generator on which the main brushes are short-circuited, the armature current being collected from two main brushes at ninety degrees to the auxiliary short-circuited ones, the polarity of this generator always remaining the same. The generator voltage is maintained constant, irrespective of speed, by a wheatstone bridge connected across the field, and as this voltage is at 36, charging 16 cells in series, it is claimed that it is impossible to overcharge the batteries. Owing to this low charging voltage, the lamp regulator used in other systems is dispensed with. It is necessary, however, to use 34-volt lamps, which are not a standard. The principal claim of this system is that there are no moving parts on the generator regulator except the automatic switch, and that it gives the battery good treatment. The system has been applied to a number of cars on the Santa Fe Railway.

Storage Batteries.

There is no doubt that if a number of electricians who operate electric-lighting equipments were asked to name the details which cause the most trouble, I am sure 90% would reply, "The batteries." It must be understood first that the battery is not a source of power, but simply retains electrical energy when charged from the axle generator or yard plant. It is composed of a number of positive and negative lead plates, which are insulated from each other by means of hard rubber or wood separators, these plates being immersed in a solution of sulphuric acid, and the whole contained in a lead-lined crate. Each set of plates are burned on to a bridge to which lead lugs are attached for connecting to the next cell. The method of determining the state of charge is usually by means of the hydrometer, the fully charged density varying from 1.215 to 1.225; the density at discharge being from 1.125 to 1.150, suitable hydrometers with glasses and tubes being specially manufactured for the purpose. The voltage test is also used, a fully charged cell reading 2.2 volts on discharge and gradually dropping to 1.8 volts per cell on full discharge. The capacity depends on the area of these plates, and as a rule in car lighting service, varies from two hundred and fifty to three hundred and fifty ampere-hours at the eight-hour rate. The dimensions of the cells principally used in Canada are 13½ inches long, 7⅝ inches wide and 19 inches high, capacity 315 ampere hours, weight, 163 pounds, so that a double battery of twenty-four cells will weigh 1.9 tons.

To maintain a storage battery in good working condition it should, as far as possible, receive about 20% more charge than discharge, but continuous overcharging will cause the plates to buckle, also create an excessive deposit of sediment, either of which will result in short-circuiting the plates, causing the cells to lose their charge and become "dead." Overcharge will also increase the evaporation of the electrolyte, which, if not replaced by adding water, will also result in damage. The ill-effects of undercharge are also to be noted, as, owing to the action of the acid on the plates, in a discharged condition a sulphate of lead is formed which will have the effect of reducing the capacity of the cell which may be removed by a continuous slow charge.

Another source of trouble is due to the current leaking to earth through the lead-lined tanks, which will take place if the bottoms of the cells are allowed to remain wet. At the point where the leakage takes place in the lining an electrolytic action follows, which eventually produces a hole in the lining, allowing the acid to leak away; this happening in one cell will probably start the rest in that battery box. To prevent this, care should be taken to keep the outside of the cells and floor of the battery boxes as dry as possible and well insulated from the iron work of the cars.

The Edison Battery.

Before leaving the subject of batteries, I would refer to the Edison battery which has been in the market for several years and to date has given favorable results. The general construction of the battery contains many different details to that of the lead type. The positive plates consist of several perforated steel tubes filled with nickel hydrate and metallic nickel plate. The negative plates consist of flat pockets of perforated steel, nickel plated, which are filled with metallic iron. The electrolyte consists of potassium hydrate in solution, with a small quantity of lithium hydrate. The elements are sealed in the containers, the cell lids being welded to the sides so that it is impossible to open the cell, which is unnecessary, owing to the tube and pocket construction of the plates, preventing any deposit of sediment. For flushing the battery, distilled water is required, as any chemical impurities introduced into the batteries will be fatal to their life. The electrolyte will last for two years, so that the only work necessary to be done on the batteries during this period is to keep them flushed and clean. The renewal of electrolyte is effected by pouring out the old solution and replacing it with new solution; this can be carried out in any yard. Owing to the falling off in capacity due to cold temperature, it is advisable to keep the battery boxes as air tight as possible and if this is done, trouble should not be experienced from this source. One of the chief drawbacks to the use of this battery is its cost, as, owing to the voltage of each cell being 1.2 volts as against 2.0 volts in the case of the lead battery, it necessitates the use of thirty-eight cells to take the place of twenty-four cells of the lead type. This increases the cost to approximately twice that of the lead battery. One point which should not be overlooked is the saving in weight, a set of thirty-eight Edison batteries (type A. 8. H.) weighing 973 pounds, as against 3,360 pounds (the weight of twenty-four lead cells), making a saving of 2,387 pounds per car. This saving in weight renders this battery easier to handle, and also saves in haulage.

Organization.

The question of organization directly interests any railway which operates electric lighting equipments and it is only by having a proper system of inspection and records that efficiency in operation and cost will be obtained.

In the past it was usual for a railway company to install a number of equipments, the installation being made by the car builders without any check or inspection whatever, and when placed in service an electrician was employed in the terminal yard to maintain them. Generally speaking, as long as the lights in the cars did not fail no particular attention was paid, and after a year or eighteen months, it was found that perhaps the batteries were worn out and required renewal and the generators were in a more or less damaged condition. The equipment was usually blamed and the next order given to a competitive firm. But since electric lighting has become more general systematic organization has been adopted with a study of the defects and their causes which arise from time to time. A few figures may serve to illustrate the effects of closely watching the performance of the equipments. Take, for example, a road with five hundred cars of all classes equipped and supposing by careful study and experiments we reduce the lamp consumption by one lamp per car per month, we effect a saving of $225 per month, or $2,700 per annum.

Again, taking the battery situation, a conservative estimate will place the life of a set at five years. Assuming we have a twenty-four batteries per equipment, and we increase their life by one year, we have, taking cost of battery as $630, as follows:

Depreciation at 5 years	$126 per annum
Depreciation at 6 years	105 per annum
Saving, per car	$ 21 per annum

Table showing in electrically lighted cars, 1911- 1914:

Multiply by five hundred cars, and we have $10,500 per annum saved.

Again, take the question of belt-life. A saving of one belt per car per annum will approximate $5 per annum per car, or $2,500 per annum on five hundred cars.

Summarizing we have:

	Saving
Saving of 1 lamp per car per month	$ 2,700 per annum
Extending the life of batteries by 1 year	10,500 per annum
Saving 1 belt per annum per car	2,500 per annum
Total saving	$15,700 per annum

The above reasoning can be applied to all the various details of the equipments which would considerably increase the total amount saved, but these figures in themselves show what may be accomplished by good management and organization.

Suspensions.

The generator suspension should be closely checked up with the object of providing for sufficient belt clearance and it will repay any railway company to give this point due consideration, as it is no idle statement that fully half the light failures and lost belts are due to insufficient clearance.

The American systems all favor a truck suspended generator and as they weigh approximately 650 pounds, the suspension members have to be heavy, causing additional weight on the truck. With the Stone system the generator is suspended on the body of the car, and I would also add that the Safety Car Heating and Lighting Company have perfected a body suspended generator which operates in a similar manner to their truck-suspended type, but weighs 176 pounds less. The advantages of the body-suspended generator are (1) Lighter suspension; (2) Generator located higher from track, and less liable to injuries from loose stones, etc.; (3) Can be inspected or removed with greater facility; (4) Longer drive, giving better efficiency.

Electrical Equipment of the Belt Line Railway of Chicago, Shops and Yards, at Clearing, Ill.

The recently completed freight yards and shops of the Belt Railway of Chicago, located at Clearing in the southwestern portion of the City of Chicago, are an excellent example of the application of electricity to the many demands of the modern railroad shop and terminal.

The yards are about four miles long, extend in a generally east and west direction, and are intended to handle the interchange of freight cars between the various lines which are part owners of the Belt Railway of Chicago. The yards have a normal capacity of about 4,000 freight cars daily in each direction and are, perhaps, the largest single facility in this country for the handling of freight cars.

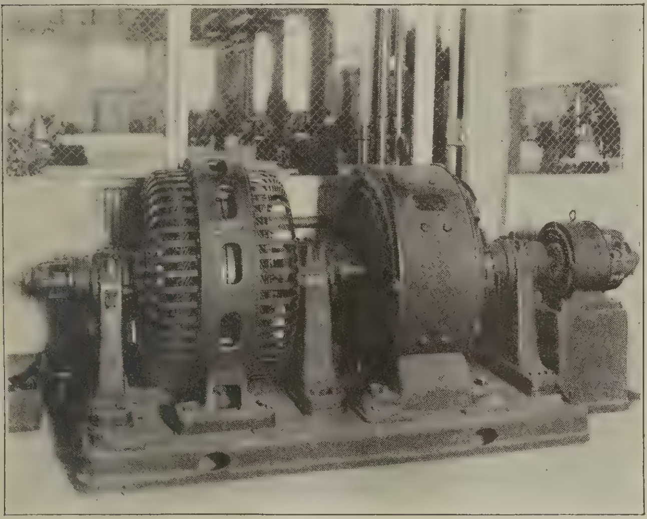

Fig. 1. Synchronous Motor Generator Set for Correcting Power Factor of the Generator System and for Furnishing D. C. Current for Variable Speed Motors.

The requirements of this huge terminal which was designed for continuous handling of freight traffic with a minimum of delay and expense, called for provision of facilities for making repairs to locomotives of the Belt Railway and freight cars handled through the terminal and a unique combination of transportation and mechanical plant wherein extensive use could be made of electricity.

Use is made of electricity in the operation of this terminal for the following purposes:

Yards.

- Lighting of freight yards and buildings.
- Operation of switches and signals at hump.
- Pumping water.
- Testing and charging of air brakes on trains.
- Operation of turntables.

Shops.

- Yard and building lighting.
- Operation of shop machinery.
- Operation of turntable.
- Hoisting coal.
- Hoisting cinders.
- Pumping sewage.
- Pumping fuel oil.

Power House.

The power house is a building constructed about twelve years ago and contained equipment which was installed to furnish steam, compressed air, water and electricity for operation of a freight yard which was built at that time and which was entirely replaced by the present yards. Electricity and water also was furnished to an adjacent industrial district and the municipality of Clearing until operation was taken over by the Belt Railway within the last year.

To adjust the power house equipment and arrangement to the requirements of the new yards and shops it was necessary to make some changes in and additions to the existing apparatus. Before this was done, a careful and thorough investigation was made as to the advisability of purchasing electricity for lighting and power from the public utility company serving this territory. Owing to the necessity of making an increase in boiler capacity even in the event of purchasing power, the existence of 700 k. w. generator capacity in good operating condition and three steam driven air compressors which were not suitable for operation with electric power and extensive alterations to piping occasioned by service since installation, it was found that no appreciable reduction could be made in labor costs and that for this particular installation the excess cost of operation with purchased power would be something over five thousand dollars per year.

The existing power equipment in the power house consisted of the following apparatus:

- 2—150 k. w., 3-phase, 60-cycle, 2,300-volt, engine-driven generators.
- 1—400 k. w., 3-phase, 60-cycle, 2,300-volt, engine-driven generators.
- 1—1,300 cubic foot capacity steam-driven air compressor.
- 1—700 cubic foot capacity steam-driven air compressor.
- 1—200 cubic foot capacity steam-driven air compressor.
- 1—10x14x12 duplex steam-operated service and fire pump.
- 1—10x14x12 duplex steam-operated service and fire pump.
- 2—8x6x10 duplex steam-operated boiler feed pumps.
- 2—200 h. p. B. and W. water tube boilers with chain grate stokers.
- 2—300 h. p. B. and W. water tube boilers with hand fired.
- 1—500 h. p. feed water heater.
- 1—5-panel marble switchboard.

All generators were excited by individual belt-driven machines operated from the engine shafts. Boilers were served by a self-supported steel stack, brick lined, 6 feet diameter by 125 feet high.

In determining what alterations should be made in the power house equipment to meet the requirements of the shops and yards, after a careful study was made of the motor and lighting loads and the probable demand from these sources, both maximum and continuous, for different periods of the day during different seasons of the year, it was found that the existing generator equipment, by taking advantage of power factor correction by means of a synchronous motor, as shown in Fig. 1, would be sufficient in capacity to meet all demands for a period estimated at five years. At the end of this time it was reasoned that the smaller generators would have outlived their usefulness and could be replaced with a large machine of suitable design and capacity.

The three belted exciters were replaced with one 25 k. w. motor-driven and one 25 k. w. turbine-operated unit, each capable of carrying full load on the generators, the motor-driven machine being provided for normal operation and the steam-operated apparatus for starting duty and relieving the motor-driven unit during emergency periods and when exhaust steam from the turbine could be used to advantage for heating.

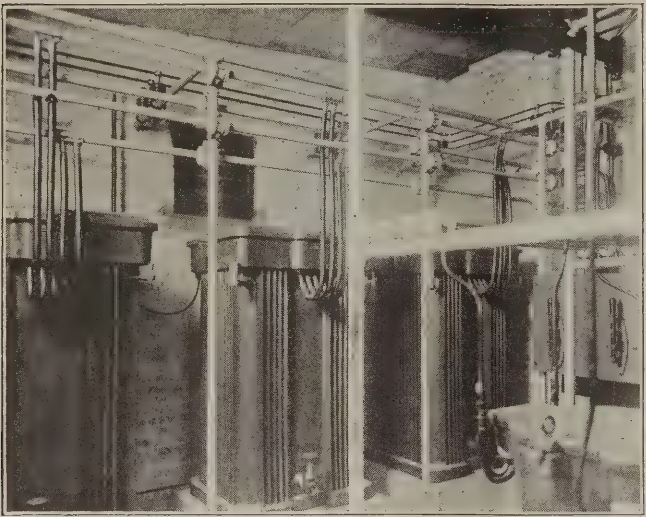

Fig. 2. Interior of Transformer House. Note the Copper Tube Bus Construction Overhead. The High Tension Buses are Painted Red and the Low Tension Buses are Painted Blue as Shown.

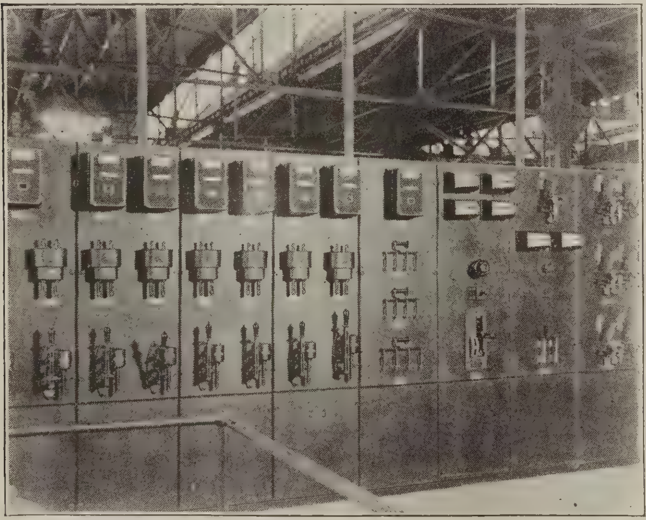

Fig. 3. Distribution Panel Mounted in the Gallery of the Machine Shop for Controlling Power and Lighting Circuits.

Switchboard.

An old switchboard of poor design was replaced with one laid out to meet the requirements of the plant and to obtain a minimum of hazard in handling the 2,300-volt current. The new board is composed of 11 slate panels divided as follows:

3 Generator panels.
1 Exciter panel.
3 Feeder panels.
1 Tirril regulator panel.
3 Series Arc Panel.

Rheostats and grids for generator and exciter control are located in the basement beneath the board. Three air-cooled single-circuit constant current transformers for the series arc circuits in the freight yards together with the station and signal system power and lighting transformers are placed in the basement under the switchboard.

The work accomplished on the electrical equipment in the power house is a good example of what can be accomplished by good design and arrangement in bringing an old plant of mediocre character to meet the requirements of modern practice as regards recording the amount of current used for various purposes, switching arrangement to insure continuity of operation and safety to power plant employes in operating the generators, switchboard and accessory apparatus.

The design and character of work behind the switchboard is extremely high class. Special attention has been given to appearance of parts usually neglected or considered of no importance and as a result the appearance of the rear of the board is entirely in keeping with the apparatus located on the front of the panels.

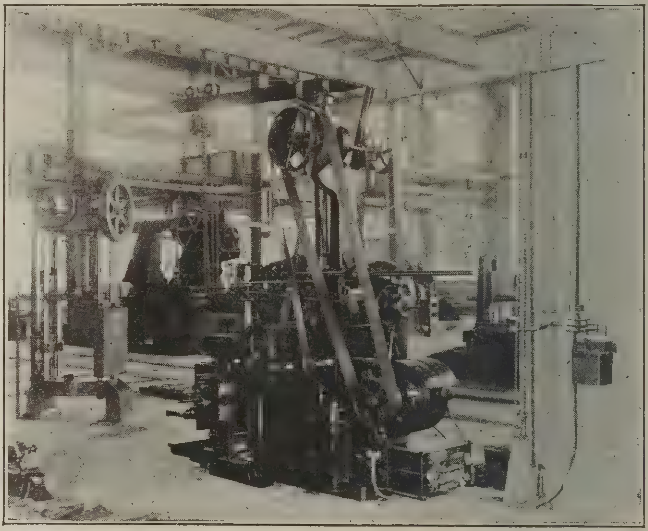

Fig. 4. A Motor Driven Draw-cut Shaper. Note the Location of the Motor, Starting Box, Resistance Grids, Etc.

In remodeling the steam end of the plant, a 450 HP. Babcock and Wilcox water tube boiler was added, one of the 300 h. p. boilers was increased in capacity to 450 h. p. by addition of the necessary amount of tube heating surface, bringing the total capacity of the plant to 1,500 boiler horsepower with the necessary draft facilities for maintaining generous overloads. The old style stack was dismantled and replaced by a Weiderholt tile and reinforced concrete chimney 7 feet in diameter by 200 feet high. A 2,000 horsepower Blake-Knowles feed water heater of the open type, a 14x9x12 duplex Blake-Knowles pump of the outside end packed pop valve type and a 300-gallon-per-minute Platt centrifugal pump operated by a Terry steam turbine were installed to replace the 500 h. p. heater and the small reciprocating pumps for heating and handling the boiler feed water. Chain grate stokers were placed under the new and remodeled boilers.

Power Generation and Distribution.

All electricity used for power and lighting purposes is 3-phase, 60-cycle current generated at 2,300 volts.

All alternating current motors are operated on 3-phase, 440-volt, and the direct-current motor equipment is for 220-volt operation.

Power for yard lighting, operating air compressors, turntables and pumps in the freight yards is carried on overhead construction between tracks of the yards. Power for use in the shops after leaving the power house is transmitted over two 3-phase, 2,300-volt, 3-conductor Kerite lead-covered cables, which are carried through Johns-Manville fiber conduits laid in one of the walls of the concrete pipe tunnel which connects the various buildings with the power house. Where changes in direction occur in the tunnel cast iron waterproofing pull boxes of special design are provided. Leaving the tunnel these cables are carried to a transformer house located adjacent to and separate from the locomotive shop. In this house which is of fireproof construction throughout and has special provisions for ventilation, as shown in Fig. 3, current for power and lighting all shop buildings and yards except the locomotive shop is transformed from 2,300 to 440 volts. Current for lighting the locomotive shop is transformed from 2,300-volt, 3-phase, 3-wire to 190/110-volt, 3-phase, 4-wire in this structure. Three 150 k. v. a. 2,300/440-volt, single-phase, oil-cooled transformers arranged so that load may be carried on two or three units are used for the power and lighting load excepting the locomotive shop. Three 20 k. v. a. 2,300/220/110 G. E. transformers are used on the 3-phase, 4-wire system which carries the lighting load of the locomotive shop.

From the transformers, two 440-volt, 3-phase power circuits and one 190/110-volt, 4-wire, 3-phase lighting circuit are carried in lead-covered cable through fiber conduits in one wall of the pipe tunnel and terminate in a 10-panel distributing switchboard located in the gallery of the machine shop as shown in Fig. 3. This switchboard contains a full equipment of watt meters for registering the power consumed in the various shops and lighting shop yards. Distribution of power to the other buildings of the shop group and for lighting the shop yards is carried overhead on steel towers and wood poles, the latter also serving as supports for the gas-filled mazda lamps which are used for lighting the shop yards and tracks leading to the roundhouse.

All lighting and power circuits leaving the distributing board are 440-volt, 3-phase, separation and transformation being effected at centers of distribution, lighting transformers being located on one of the steel transmission towers and in a few instances on poles.

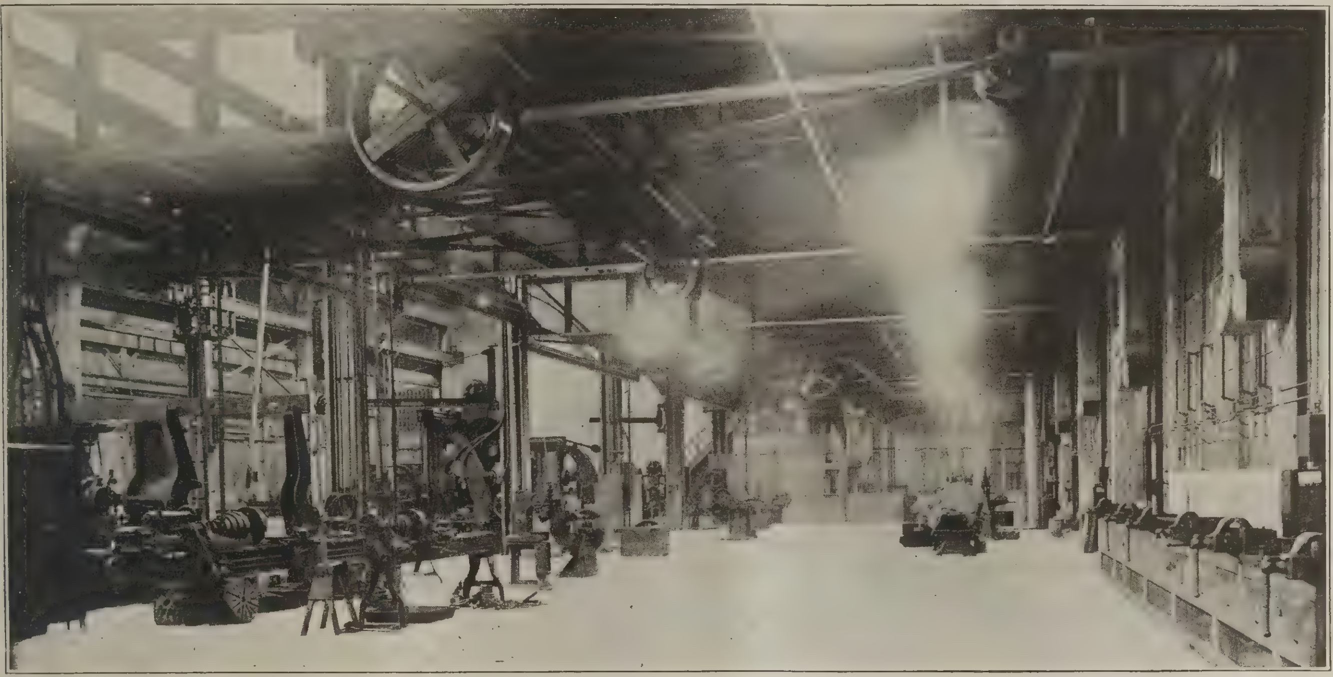

Fig. 5. Night View Taken Without Flash in the Light Bay of the Machine Shop. Note the Great Detail with Which All Objects May Be Seen, Also the Uniformity of the Illumination and the Complete Absence of Shadows. 150-watt Mazdas are Mounted 16 ft. High in Enameled Steel Reflectors.

All wiring inside buildings is in sherardized conduits and Appleton Electric Co., "Unilets" are used throughout the entire installation.

Locomotive Shop.

From the main distributing board in the gallery 3-phase, 440-volt current is carried throughout the shop for operation of alternating current motors.

Located in the tool room enclosure on the ground floor is a 100 k. w., 220-volt Westinghouse direct-current motor generator, the motor end of which is a 440-volt synchronous motor with separate exciter direct connected to the motor shaft. This motor generator set, as shown in Fig. 1, was provided primarily for current factor correction and to take advantage of the well known characteristics of a synchronous motor generator set operating under mechanical load and of obtaining a suitable amount of 220-volt continuous current for operating direct-current motors for machine tools where speed adjustment by varying the speed of the motor is of prime importance. The operation of the synchronous motor generator unit is controlled from the distributing switchboard in the gallery as are all direct current power circuits which serve the light and heavy bays of the machine shop.

Special attention has been given in this installation to provide an electrical equipment which is as good as the combination of excellent design, best of materials and first-class workmanship would produce and the aim of the designer seems to have been realized as the installation is probably without an equal among railroad shops in this country. All squirrel a. c. motors 7½ h. p. and above are equipped with starting compensators and overload relays. Extensive use is made of a push button device of special design operating in connection with the no-voltage release attachment on the compensators, for emergency and easy stopping of motors. All group motors such as that shown in Fig. 5 may be stopped from two widely separated points in addition to using the compensator in the regular manner.

A. c. motors under 7½ h. p. are started by throwing directly on the line, Westinghouse Type H. plain overload circuit breakers being used for the purpose. All d. c. motors are protected by the same type of breaker, use being made of a no-voltage release attachment where the emergency stop feature is necessary for instantaneous stopping of motor.

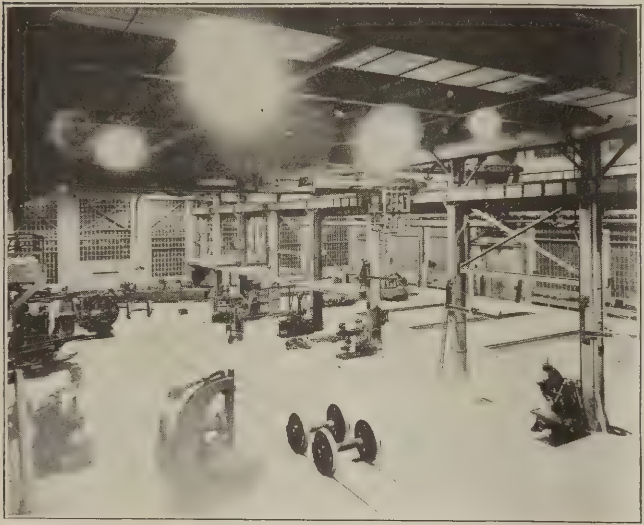

Fig. 6. Night View of the Heavy Machine Bay with Erecting Bay in the Distance. These Bays are Lighted by Long Burning Flaming Arc Lights Mounted High Above the Crane Runways.

Convenience and accessibility of motor control on machinery has received a great amount of consideration and in all cases the starting or controlling device or connection to same are located in close proximity to the working position of the operator.

The erecting and boiler shops which occupy one bay of the building, the heavy machine bay and the smith shop are lighted by Westinghouse multiple flaming arc lamps equipped with a special reflector designed for this installation. The lamps in the erecting and boiler bay are mounted 50 feet above the floor and in the heavy bay and the smith shop are 35 feet above the floor. The lighting effect produced from the use of flaming arc lamps with special reflectors is particularly pleasing and the distribution is excellent as is indicated on the accompanying photograph taken at night shown in Fig. 6.

The light machine bay is lighted by 250-watt mazda lamps mounted in Benjamin enameled steel reflectors. The illumination in this portion of the building also is excellent, as may be seen from the night photograph, Fig. 5.

Provisions for extension cord lighting are provided by numerous Westinghouse roundhouse type receptacles placed at accessible points. Recessed in the side walls of the erecting shop pits are placed 6 receptacles for extension lighting as shown in Fig. 7. The receptacles in this location are well protected from mechanical injury.

A floor box of novel design is used for extension cord lighting in the boiler shop. The Westinghouse roundhouse receptacle is used and is so placed in the box that trouble from waste water used in testing boilers is avoided. These floor boxes extend down the middle of the bay to avoid running long extension cords from the walls or columns.

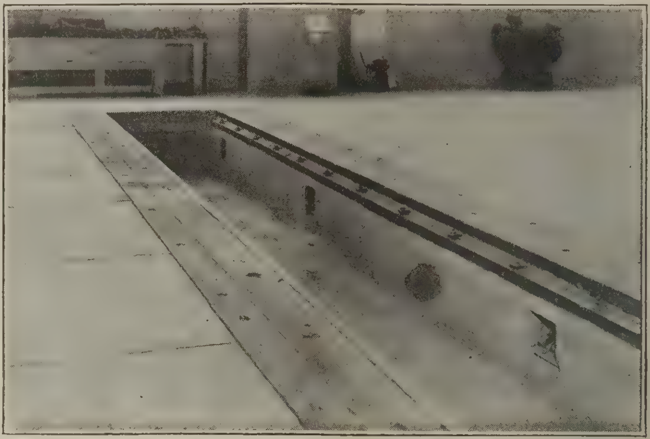

Fig. 7. Locomotive Pit in the Erecting Bay. Note the Extension Cord Receptacles Mounted in Recesses in the Side Wall of the Pit.

Roundhouse.

A well designed lighting system has been provided in the roundhouse which is a brick structure containing 20 stalls measuring 90 feet from inside posts to inside of outer circle walls.

Before the lighting scheme was adopted, experiments were conducted at the 51st street roundhouse of the Chicago and Western Indiana Railroad, which has a cross section similar to that of the Clearing roundhouse. Results of these experiments, which included comparison of lighting effects produced with various forms of suspended and wall reflectors located at different spacings and heights above the floor, led to the adoption of an arrangement in which four suspended lights per stall are used, the lights being spaced 22 feet apart the lamp nearest the outer circle wall being placed 10 feet from the inside face of the

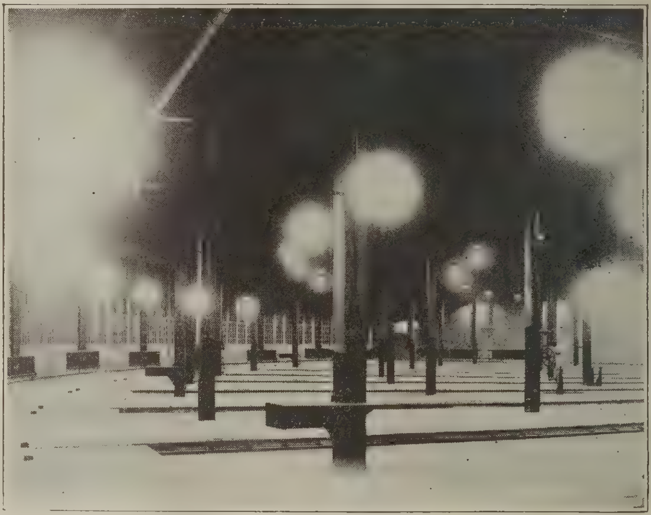

Fig. 8. View Showing General Illumination of the Roundhouse at Night. Note the Great Uniformity of this Lighting. 4 150-watt Mazdas in Enameled Steel Reflectors Mounted 13 Ft. High Are in Each Stall Except in the Outer Ring, Where 100-watt Lamps Are Used.

wall. Benjamin 14-inch enameled steel reflectors with 100-watt mazda lamps are used for the end lights between each stall, the lamp near the outer circle being placed 12 feet above the floor while the lamp nearest the inner circle is located 13 feet above the floor.

The illumination provided by this lighting system is abundant and is very uniform, as shown in Fig. 8. The two inside units consist of Benjamin 16-inch enameled steel reflectors fitted with 150-watt mazda lamps.

All wiring inside the house is run inside sherardized conduit and special attention is given to protecting the wiring from the destructive action of the gases.

The lighting units between each stall are operated on two circuits controlled by push button switches placed in a common receptacle unit. One switch controls the outer circle lamp and the other the remaining three units. The circle outside the roundhouse adjacent to the turntable is lighted by means of three 250-watt mazda lamps placed in Benjamin enameled steel angle type reflectors. The lighting effect from these units is very good and is a decided improvement on the results obtained from the usual proceeding of using a vertical reflector, tilted. On the posts between stalls are placed four Westinghouse roundhouse receptacles for extension cord lighting, and these are arranged for connection to the current supply independent of the push button switches controlling the lighting units.

The engine wheel drop pit extends over three stalls and is equipped with Westinghouse receptacles for extension lighting, and 25-watt lamps permanently placed in beveled recesses formed when the concrete was poured.

The mains for lighting the roundhouse are carried on the outer circle walls on Pierce galvanized brackets which are fastened to wood inserts laid in the brick of the wall. The three-wire, 220/110-volt system is used and each circuit is fused with a double pole plug cut out, placed in a McFell special roundhouse box located on the wall outside of the house. Lights are placed over all outside circle and end wall door openings, the lamps being controlled by separate push button switches placed inside of the house.

Wood Mill.

The wood mill is provided with a complete equipment of machinery for manufacturing all finished wood stock used in the repairs of cars and locomotives at Clearing and other points on the Belt Railway. Machinery for handling car wheel and axle work also is installed in this building.

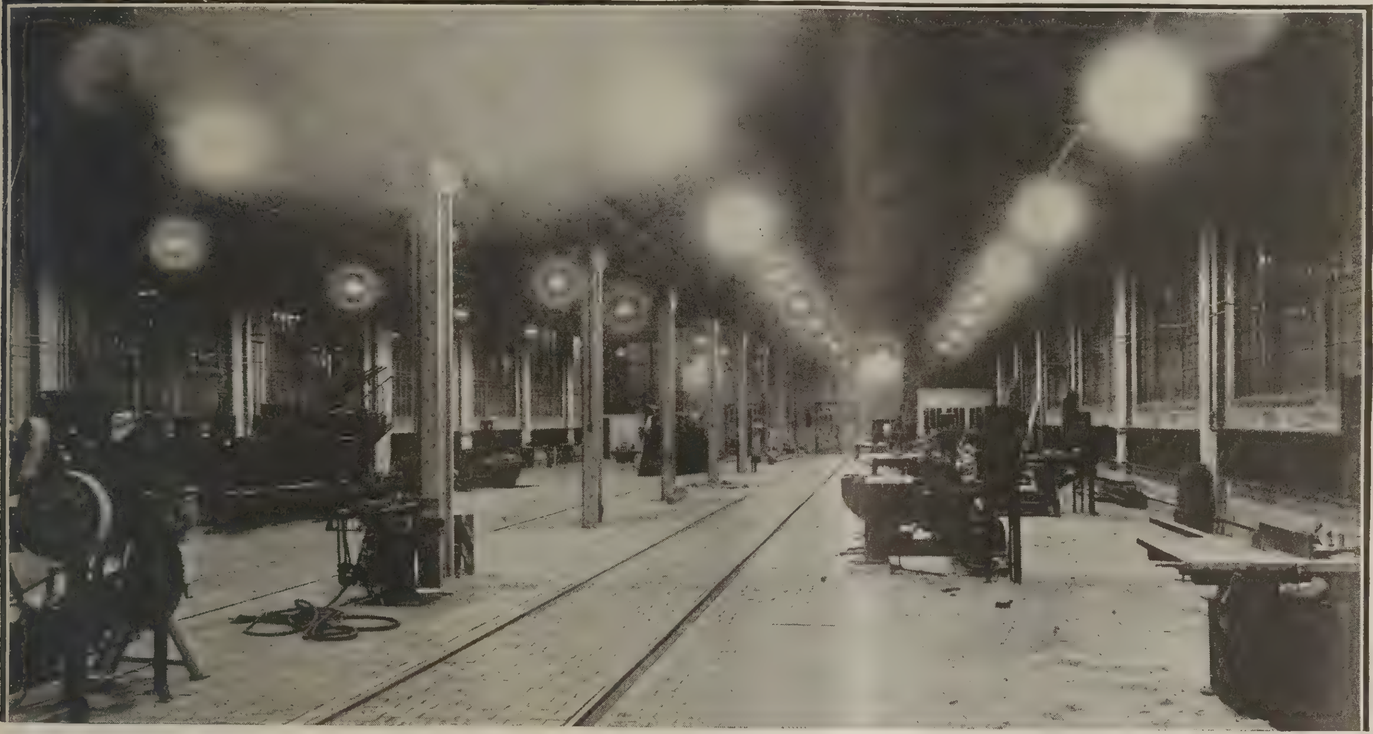

Fig. 9. Night View Taken Without Flash of the Interior of the Wood Shop. Note the Absence of Glare, Uniformity of Illumination With No Shadows, and the Distinctness With Which Detail May be Seen.

All machinery is driven by individual 440-volt, 3-phase motors there being no overhead belts of any description. The floor of this building is creosoted wood blocks with concrete base. Conduit between walls, columns and machines is laid in grooves in the concrete floor base and is easily accessible by removing the wood blocks above, the location of the conduit being outlined in paint on the floor. Lighting of this building is effected by means of 250-watt tungsten units mounted in Benjamin 16-inch enameled steel reflectors located 15 feet from the floor. The lamps are operated four on a circuit, are spaced about 15 feet apart and suspended from the trusses which are 20 feet center to center. Control of lights is from a central panel box. A two-way circuit controls a watchman's circuit consisting of five 60-watt tungsten lamps with push button switches located at each of the end doors inside of the building. The accompanying photograph Fig. 9 taken at night in this building shows a nearly ideal lighting installation for a condition where high speed knives and saws are in operation. Note that the reflectors screen the lamps so that there is no glare in the eyes of the workmen. The camera here gives a fair idea of the uniformity and effectiveness of the lighting system.

Boiler Washing System.

A unique departure from usual practice is the use of motor-driven centrifugal pumps of the Worthington turbine type for furnishing hot water to the roundhouse for washing out and filling locomotive boilers. These pumps are each operated by a 35 h. p., 1,800 r. p. m. Westinghouse motor of the ship ring type, stopping and starting being effected automatically on variation of pressure in surge tanks by a Cutler-Hammer control panel and diaphragm pressure regulator, as shown in Fig. 10.

A small motor driven pump is located in the same room with the boiler washing system apparatus and furnishes hot water for use in lavatories throughout the shops and offices.

A unique method of heating the roundhouse lavatory and locker room which is located under the same roof and adjacent to the boiler washing system apparatus consists of using a small motor-driven propeller fan located in an opening in the dividing wall to circulate waste heat radiated from the boiler washing tanks to the lavatory and locker room.

Storehouse and Office.

The storehouse, in the second story of which are located the offices of the master-mechanic and the store keeper, is a brick structure in which special attention has been given to lighting effects. Ceiling lamps with opal shades are used in all offices. The material cases in the storehouse are placed transversely with the building and are spaced 12 feet center to center. Centrally located over the space between cases are 60 watt lamps with 10 inch enameled steel reflectors. The center aisle at ends of material cases also is lighted by similar units and an excellent illuminating effect is obtained considering the obstruction to distribution offered by the cases. The wiring in the oil storage and handling rooms is in conduit with waterproof and vaporproof fixtures. Control of all lights in the oil storage room is from a panel in the settling room.

Water Supply Pumps.

Water for use in locomotives operating at the terminal is obtained through connection with the mains of the City of Chicago. To obtain a sufficient storage and uniform pressure, two booster pumps were installed each having a capacity of 1,000 gallons per minute against a 39 foot head. The pumps are located in a brick structure at the east end of the yard, are of the Worthington centrifugal volute type, each operated by a 15 h. p., 1,200 r. p. m., 440 volt, 3-phase, 60-cycle, slip ring type motor. Automatic control of the pumps is obtained by using a Cutler-Hammer automatic control panel. As the pumps are provided in duplicate, a throw-over switching arrangement is used to make the control operable on either pump. The governor is designed to allow of a maximum variation in head of 5 feet in the tanks and is of the diaphragm type. All wiring in the pump house is in conduit and the entire electrical installation presents a very neat appearance, indicative of careful workmanship and design.

Drainage Pumps.

An existing sewer at a level above that of the turntable, cinder, coaling station and engine wheel drip pits necessitated the installation of a pump, the drainage of which is effected by two 5-in. vertical shaft type sump pumps. These pumps are operated by 5 h. p., 900 r. p. m. Westinghouse vertical 440 volt motors and float actuated switches arranged to control the pumps progressively in case of heavy rainstorms which are common in this territory during certain seasons of the year. These pumps have been in operation for over a year and have given entire satisfaction with practically no attention, other than inspection.

Turntables.

Three turntables are in use, one serving the roundhouse and one at each end of the yards. The tables are 90 feet long and each is operated by a Nichols electric tractor of the latest type. Each tractor is equipped with a 20 h. p. General Electric slip ring type motor and reversible drum type controller located in a neat cab above the tractor proper. Service to the tractor is led underground from a cutout box in the roundhouse, and on poles in the yard installations. Arrangement is provided for segregating the entire underground portion of the line by fused knife switches in the tractor cab and cutout boxes. At the center of each table is a waterproof box of special design, made of cast iron and which contains the contactor device. Special attention has been given to guard against interruption of service by making all construction heavy, permanent and waterproof. Illumination of the end of table opposite the tractor is effected by mounting a Crouse Hinds headlight on a support, suitably placed to direct light on the rails. The headlights are removable, a waterproof socket being used.

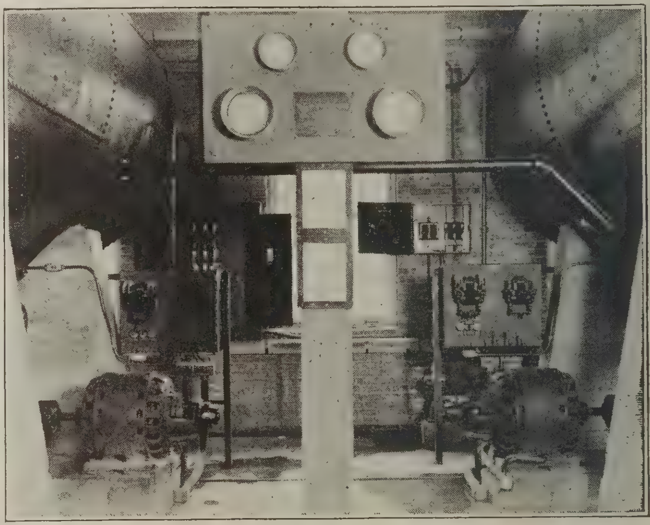

Fig. 10. Boiler Washing Plant. Automatic Controllers Are Mounted on Panel Back of Each Motor, as Shown. These Are Operated by an Automatic Pressure Diaphragm.

Cinder Pit Hoist.

The cinder pit is of the type generally used on the Pennsylvania Lines West. Buckets containing the cinders are raised and dumped by a Lidgerwood single drum hoist operated by a 5 h. p., 1,200 r. p. m. General Electric slip ring motor and a drum type controller. A limit switch is used to prevent overtravel of the bucket when hoisting and operates a solenoid brake on the motor shaft through the action of a no-voltage release attachment on an oil circuit breaker.

Coaling Station.

The coaling station is a reinforced concrete structure having a storage capacity of 400 tons and serves four tracks with coal and sand. The coal hoisting mechanism is of the Roberts and Schaefer balanced bucket type using two buckets each holding 2½ tons and having a hoisting capacity of 125 tons per hour.

The hoist is operated by a 20 h. p., 900 r. p. m. slip ring type, General Electric motor equipped with solenoid actuated brake placed on one end of motor shaft. Operation of the hoist is entirely automatic, a Cutler Hammer controller of special design being used. All operations of stopping, starting, reversing, slowing down for dumping and filling buckets are performed with a high degree of precision on this equipment through switches placed in the hoisting shaft. No attention is required from the operator other than actuating a push button when it is desired to start or discontinue the hoisting of coal.

Air Brake Charging Plant.

Located in the departure yard at each end of the freight yards is an air compressing plant for testing and charging of air brakes on trains previous to departure. The compressors are vertical three cylinder type operated by 20 h. p., 900 r. p. m., slip ring type 440 volt motors. A feature of the installation is the use of automatic control for stopping and starting the compressor which enables the motor to come to full speed before the load is applied, an arrangement which is very successful and has a minimum of effect on the voltage regulation of the line.

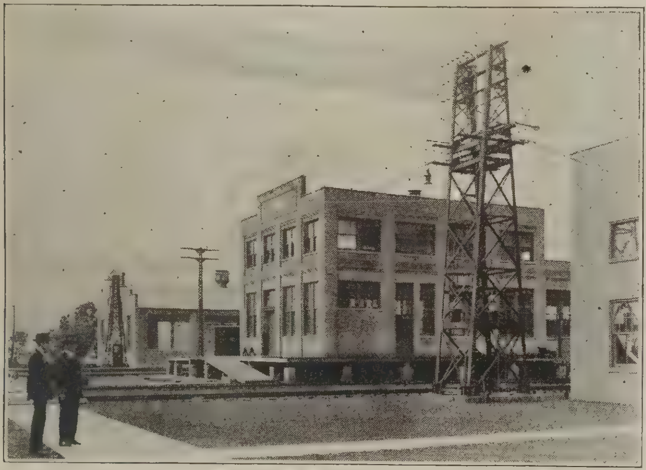

Fig. 11. View Showing Overhead Distribution System.

The plants are equipped with reservoirs, cast iron atmospheric aftercoolers, water cooling system for the compressor water jackets. The electrical work is simple, of excellent design and arranged to operate automatically and with a minimum of attention.

Signals and Interlocking.

Current for actuating the electro-pneumatic switching and signal apparatus serving the hump is furnished from two 20 volt motor generator units in the power house which operate in connection with storage batteries. The batteries are located in a separate building connected to engine room. A switchboard of neat design for controlling the battery charging is located in the engine room adjacent to the battery house. This board also controls the lighting service to the signal and switching system lamps, 110 volt alternating current being used for this purpose.

Yard Lighting.

The freight yards are illuminated with 110 Westinghouse type series a. c. flaming arc lamps controlled by three Westinghouse 50 lamp, single circuit constant current transformers located in the power house. The arc lamps are mounted in angle iron frames on 40 foot poles.

Current distribution is entirely overhead excepting in a few instances where long spans and traffic conditions made underground service desirable.

Poles which carry power lines are used for mounting lamps to provide general illumination and all switches and ladder tracks are lighted by lamps placed on poles spaced to give a desirable degree of light intensity at the points of greatest traffic.

Lighting of the shop yards is provided by 300 watt, twenty ampere, 600 c. p. mazda lamps in General Electric pendant type fixtures for outdoor service. The fixtures are mounted on poles and are provided with compensators for operation on 110 volt multiple circuits. The lights are controlled from the distributing board in the locomotive shop.

The design of the entire electrical installation with exception of the signal and interlocking plant was handled in the office of Mr. E. H. Lee, vice-president and chief engineer, under the direction of Mr. Willard Doud, consulting engineer, 538 S. Dearborn street, Chicago. The construction work necessary for lighting the freight yards was handled by the railroad company forces under direction of Mr. W. H. Robson, superintendent of telegraph, and Mr. L. B. Abbott, electrical engineer. All electrical work at the shops was executed by the W. A. Jackson Co., electrical contractors, 37 W. Van Buren street, Chicago, under supervision of Mr. John Strandell, electrical inspector of the railroad company.

The motor equipment of the plant consists of the following apparatus:

Alternating Current Motors

Horse Power	Speed	Type	Application
			Machine Shop New Tools.
50	680	S. R.	Main Hoist 150-ton Crane.
50	680	S. R.	Main Hoist 150-ton Crane.
30	850	S. R.	Main Hoist 150-ton Crane.
15	850	S. R.	Trolley 150-ton Crane.
15	850	S. R.	Trolley 150-ton Crane.
50	680	S. R.	Bridge 150-ton Crane.
30	850	S. R.	Hoist 10-ton Crane.
30	850	S. R.	Bridge 10-ton Crane.
5	790	S. R.	Trolley 10-ton Crane.
30	850	S. R.	Hoist 10-ton Crane.
30	850	S. R.	Bridge 10-ton Crane.
5	790	S. R.	Trolley 10-ton Crane.
40	900	S. R.	Sellers 90″ Driving Wheel Lathe, Drive.
2	1200	S. C.	Sellers 90″ Driving Wheel Lathe, Quartering.
5	1200	S. C.	Sellers 90″ Driving Wheel Lathe, Tail Stock.
10	1200	S. C.	Lucas No. 33 Hor. Boring Machine.
15	900	S. C.	Chambersburg 600-ton Wheel Press.
10	1200	S. C.	Bullard 36″ Vertical Tarret Lathe.
15	900	S. C.	Baker No. 1½ Heavy Duty Drill.
25	900	S. C.	Cincinnati 84″ Boring Mill.
2	1800	S. C.	Ransom 20″ Wet Grinder.
5	1200	S. C.	Watson Stillman 60-ton Forcing Press.
5	1200	S. C.	Ransom 18″ Double Emery Grinder.
5	1200	S. C.	Ransom 18″ Double Emery Grinder.
5	1200	S. C.	Ransom 18″ Double Emery Grinder.
3	900	S. C.	Acme 1½″ Dbl. Head Staybolt Cutter.
2	900	S. C.	Hammet Link Grinder.
3	1200	S. C.	Cincinnati Bickford 36″ Radial Drill.
3	1200	S. C.	American 24″ Radial Drill.
3	1200	S. C.	Lodge and Shipley 16″ Tool Room Lathe.
1	1200	S. C.	Wilmarth & Mormon Drill Grinder.
10	1200	S. R.	American 30″x14′ Engine Lathe.
2	1200	S. C.	Stoever 4″ Pipe Machine.

2	1800	S. C.	Morton and Plummer No. 15 Post Drill.
2	1800	S. C.	Morton and Plummer No. 15 Post Drill.
2	1800	S. C.	Ransom 12" Dbl. Bench Grinder.
10	600/1200	S. R.	Morton 32" Draw Cut Shaper.
50	900	S. R.	Sirocco No. 13 Heating Fan.
15	900	S. C.	Group No. 1.
5	900	S. C.	Group No. 2.
			Machine Shop Old Tools.
5	450/900	2 Speed	Putnam Axle Lathe.
5	1200	S. C.	Whitcomb 39"x9' Planer.
3	900	S. C.	Bickford 60 Radial Drill.
2	1200	1 Phase	White 18"x8' Portable Lathe.
			Wood Mill New Tools.
50	900	S. R.	Berlin No. 14 20"x14' Timber Sizer.
20	1200	S. C.	Greenlee No. 405 36" Rip Saw.
15	900	S. C.	Greenlee No. 456-A Auto Cut-Off Saw.
10	900	S. C.	Fay Egan No. 2 Auto Cut-Off Saw.
15	900	S. C.	Greenlee No. 402-H Sill Gainer.
15	900	S. C.	Greenlee No. 329 4 Spindle Borer.
15	900	S. C.	Greenlee No. 238-P Vertical H. C. Mortiser.
5	1200	S. C.	Greenlee No. 478 Double Arbor Saw.
5	1200	S. C.	American 24"x10 Pattern Lathe.
7½	3600	S. C.	American No. 5 24" Surfacer.
2	1200	S. C.	Covel No. 35 Saw Gummer.
2	1200	S. C.	Covel No. 103 Knife Grinder.
			Wood Mill Old Tools.
2	900	S. C.	48" Grindstone.
5	1800	S. C.	Woods 36" Band Saw.
2	900	S. C.	Woods Small Mortiser and Borer.
5	1800	S. C.	Woods 20" Jointer.
			Car Wheel Shop New Tools.
20	900	S. C.	Putnam No. 2 48" Car Wheel Borer.
20	900	S. C.	Bridgeford Double Head Axle Lathe.
5	1200	S. C.	Ransom 18" Double Emery Grinder.
			Car Wheel Shop Old Tools.
7½	900	S. C.	Niles 36"x12' Journal Lathe.
3	1200	S. C.	Aurora 25" Vertical Drill.
3	1200	S. C.	Acme 1½" Dbl. Head Bolt Cutter.
7½	900	S. C.	Niles 300-ton Car Wheel Press.
5	900	S. C.	**Boiler Shop New Tools.**
			New Doty No. 17 Punch.
5	1200	S. C.	New Doty 10" Horizontal Punch.
2	1200	S. C.	Mathews Flue Cutter.
2	1200	S. C.	Mathews Flue Cutter.
5	1200	S. C.	Hartz Flue Welder.
3	1200	S. C.	Ryerson Hot Saw and Expander.
30	900	S. R.	Flue Rattler.
3	3600	S. C.	Flue Furnace Blower.
5	1200	S. C.	Ransom 18" Double Emery Grinder.
3	3600	S. C.	Flange Fire Blower.
			Boiler Shop Old Tools.
30	900	S. R.	Niles 9' Bending Rolls.
7½	1200	S. C.	Long and Allstater 30" Shear.
			Blacksmith Shop New Tools.
3	900	S. C.	Beaudry No. 4 Power Hammer.
5	1200	S. C.	Bradley 100-lb. Power Hammer.
5	1200	S. C.	New Doty 17-D Bar Shear.
10	1200	S. C.	Acme 1½" Forging Machine.
2	1200	S. C.	American 48" Grindstone.
5	1200	S. C.	Ransom 18" Dbl. Emery Grinder.
20	3400	S. C.	General Electric Centrifugal Compressor.
2	3600	S. C.	Auxiliary Blower.
			Yards.
20	900	S. R.	400-ton Coal Chutes.
20	1200	S. R.	90' Nichols Turntable Tractor, East End.
20	1200	S. R.	90' Nichols Turntable Tractor, West End.
20	1200	S. R.	90' Nichols Turntable Tractor, Roundhouse.
20	900	S. R.	100 cu ft. National Compressor, East End.
20	900	S. R.	100 cu ft. National Compressor, West End.
7½	900	S. R.	Lidgerwood-Hoist—Cinder Pit.
5	720	S. R.	200 Gallon 4" Centrifugal Sump Pump.
5	720	S. R.	200 Gallon 4" Centrifugal Sump Pump.
15	1200	S. R.	1000 Gallon 6" Centrifugal Booster Pump.
15	1200	S. R.	1000 Gallon 6" Centrifugal Booster Pump.
			Power House.
7½	600/1200	S. R.	Stocker Drive.
30	900	S. C.	Motor Driven Exciter.
3	1800	S. C.	Signal Motor Generator.
3	1800	S. C.	Signal Motor Generator.
			Storehouse.
2	1200	S. C.	Fuel Oil Pump.
			Boiler Washing System.
35	1800	S. R.	300 Gallon 100-lb. Pressure Washout Pump.
35	1800	S. R.	300 Gallon 100-lb. Pressure Filling Pump.

DIRECT CURRENT MOTORS

Machine Shop.

7½	450/1800	Comp.	Sellers 20" Slatter.
12	375/1500	Shunt	Niles 60" Boring Mill, Drive.
3	1200	Comp.	Niles 60" Boring Mill, Rail.
15	400/1600	Reversing	Pond 42"x10' Planer, Drive.
3	1200	Comp.	Pond 42"x10' Planer, Rail.
15	500/1500	Shunt	Springfield 42"x9' Engine Lathe.
5	400/1600	Shunt	Bullard 30" Boring Mill.
3	300/1200	Shunt	Niles Radial Drill.
2	300/1200	Shunt	Putnam 20"x8' Bolt Lathe.
2	300/1200	Shunt	Bradford 14"x6' Bolt Lathe.

Alumina Insulation for Aluminum.

In a recent issue of the *Electrician* (London), the installation of alumina wires by oxidation was discussed. It is a well known fact that alumina readily oxidizes to a slight extent on the surface. This at once has its beneficial and unbeneficial effects, one of the advantages is that this property of alumina makes it a very efficient electrofier in certain electrolytes, and enables a motor to withstand several hundred volts after proper treatment. The surprising thing about it is, however the rapidity with which the blocking action takes place, and that current is able to flow so rapidly in one direction during half the period and is practically prevented doing so during the other half, one of the bad points of oxidation is the difficulty in making satisfactory alumina joints and solders.

A great many attempts have been made to make use of this easy oxidation as a method of insulating aluminum wires, but no great success has been achieved until lately. The coating of oxide of this form was weak mechanically and unable to stand high voltages, but recently a process has been worked out which promises to open up a new field of usefulness for this method of insulation.

C. E. Skinner and L. W. Chubb have used a process consists in forming a wire into the leader of a rectifier using an electrolyte such as borax, ammonium nitrate, or sodium silicate. The wire passes through this bath at the rate of 150 feet per minute. When wires so treated are twisted together with abrasion they are able to stand a pressure from 200 to 500 volts between them. On account of its thinness the volume is quite flexible and consequently the wire can be bent sharply without being damaged.

One of the greatest advantages of this form of installation is that it is not inflammable and can be run at much higher temperatures than are customary with copper. It has been stated that such coils can be heated until the aluminum becomes molten. The current is decreased gradually and the coil does not fall to pieces in cooling.

This process is described in a paper read before the American Electro Chemical Society.

Shop Motor Section

Two Phase Windings and Rotor Contruction

J. H. Wickman

(Sixth Article)

The distance between two consecutive negative poles or two positive poles on any machine is known as the pole pitch, and is measured in terms of electrical degrees. Therefore, the distance between two similar points on adjacent like poles is 360 electrical degrees. In a two-pole machine the electrical degrees and the mechanical degrees would be the same. Two phase windings, as has already been pointed out, are displaced from one another by 90 electrical degrees, or one-half of 1 pole arc.

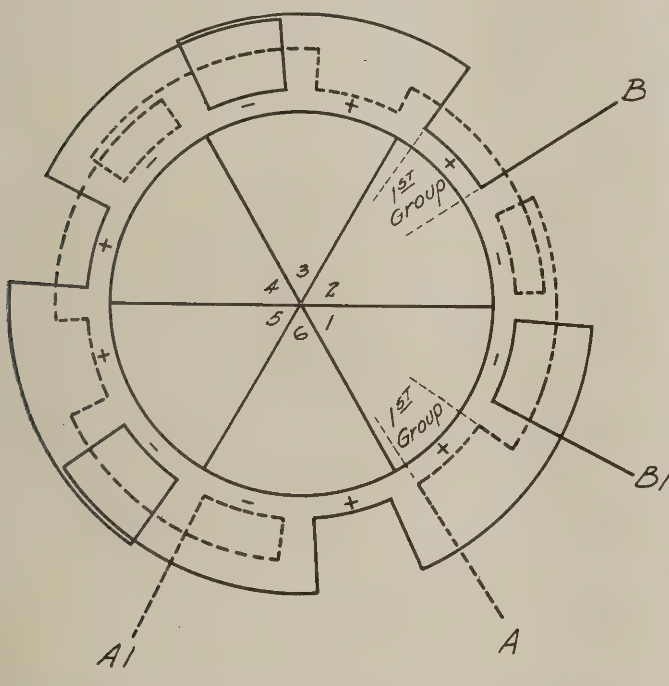

Fig. 14. Simplified Diagram of a 6-pole Two-Phase Machine Representing Any Form of Winding With Any Number of Coils.

The simplified wiring diagram for end connections is fully applicable to two-phase work. The coil signs refer to the manner in which the coil is to be connected, showing whether the terminals are to be reversed or connected straight. The diagram of a 6-pole two phase winding is shown in Fig. 14. This may represent any number of coils per group that is desired. It would be possible to make an endless number of diagrams representing different two phase connections, the only difference being additional poles or a different operating voltage. However, some manufacturers recommend that poles of one polarity be connected consecutively together and then connected to the poles of the opposite polarity.

It might be well to recall at this point one method which was described to produce a two-speed, three-phase winding. That is, the group winding shall be so placed that the induced poles are of one polarity, the poles of opposite sign being of consequent formation.

Rotor Windings.

In the development of the induction motor through its first experimental stages the construction of the stator has changed but little except that the frame design has has been slightly altered and the form of slots has been varied in the newer types of motors. The rotor element, however, has experienced considerable change since the first experiments were made. The first type was a wound rotor having but one series circuit which, during operation, was short circuited. This had the disadvantage of operating at a low power factor and with very low efficiency, which suggested the use at two rotor circuits, giving an increased efficiency and better power factor. Tests showed that the efficiency and power factor were improved with each additional circuit, and this led to the use of short-circuited bars, which is found in the modern squirrel cage type of rotor.

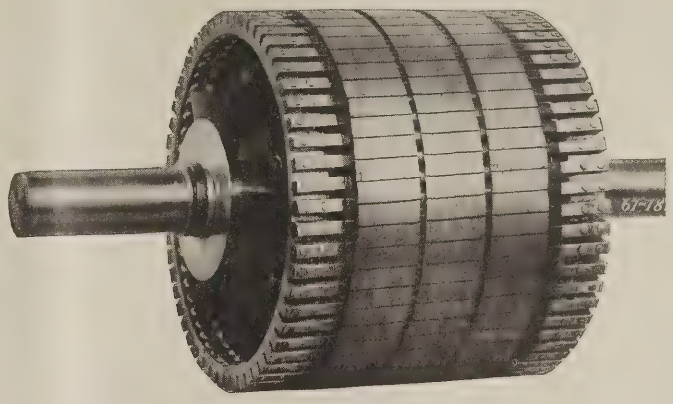

Fig. 15. Squirrel Cage Rotor With Conductors Riveted to End Rings and Soldered Into Place.

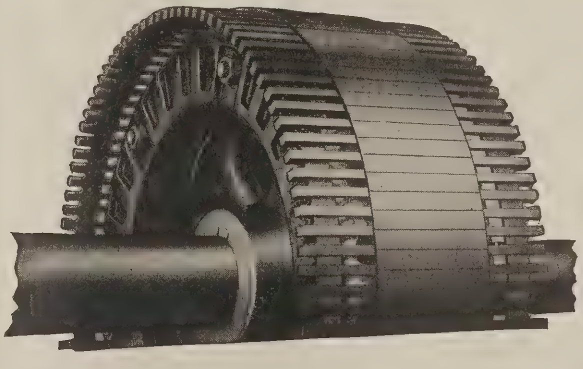

Fig. 16. Rotor Manufactured by the General Electric Co., in Which Bars Are Embedded in Slots With Insulating Fireproof Cement and Welded to Short Circuiting Rings.

The rotor shown in Fig. 15 is made up of a number of insulated bar conductors, which are riveted to end rings which serve to short circuit the former. The end rings are dipped in a solder bath to insure good electrical contact. No two manufacturers design their rotors exactly alike, but one principle may be applied to all of them; that is, the insulated bars are put into slots in the laminated core and short circuited.

Only until two or three years ago the rotor has been the weakest element of the induction motor. At this time manufacturers began making rotors similar to the one shown in Fig. 16, in which the bars are embedded in the slots in an insulating fireproof cement and are welded at both ends to short circuiting rings. A rotor of this construction is practically indestructible if it is not required to carry an overload long enough to burn the bars open.

A limited amount of reliable data in regard to the insulation of the conductor bars can be had. Practical experience has shown that when the insulation of the rotor bars becomes charred and lifeless, allowing the bars to come in contact with the laminations of the rotor, that the slip is increased and the torque decreased to such an extent that the motor is unable to carry its rated horse power. Some manufacturers claim that the insulation of the rotor bars has little effect on the operation, but little credence should be given this theory, as motors of a commercial size are not able to pull their rated load without excessive heating unless such insulation is provided.

All of the older types of rotors like the one shown in Fig. 15 are liable to be injured by overheating. This causes the solder to be thrown off from the connections between the bars and the short circuiting rings. This may be caused in two ways—first, by the motor being overloaded, and second, by overheating the motor on too low a voltage, the effect of which is to decrease the torque, thereby increasing the current consumption with its resultant heating effect. A positive indication that such trouble has occurred and that the bars are loose is excessive sparking when the motor is being started. A rotor damaged in this way should be removed, the bars taken out and thoroughly cleaned, and replaced, making a good electrical connection between the bars and rings, then riveted or bolted as they were originally. The connections should then all be soldered.

Wound Rotors.

It is often desirable to use wound rotors in induction motors, so that the resistance may be inserted in the rotor circuit and the speed controlled thereby. The windings on most all large size wound rotors are of the three phase wave form, as was set forth in the last article. Certain classes of single phase motors, however, are not wound in this way. The stator may be wound with any number of phases, for any such polyphase winding will give a uniformly distributed rotating field. But the characteristics of the motor are not always improved to an extent that would justify using a polyphase winding on the rotor with its additional collector rings, external resistance and complicated controllers.

The trouble that occurs most frequently to a wound rotor is open circuits. A simple test to locate these is to remove the brushes from the rings and apply current to the stator. Then test across the rings with one or more lamps in series, so that the voltage of the lamps will about equal the rated voltage of the machine, as shown by the name plate. These lamps should light up between any of the rings, and if they do not, it indicates an open circuit. If this test shows that the winding is all right, the testor should look for the open circuit in the external circuit.

Stator Winding Troubles.

There is much wisdom in the saying that the windings of an alternating current machine are either right or all wrong, for a very small error or accident will greatly affect the machine's operation. One of the most frequent difficulties with such windings is caused by a few coils burning out or grounds. One ground will not affect the operation of a motor, but all machines should have their windings kept clear of grounds if possible, for when more than one occurs the short circuit of one or more coils will result. This will either blow out the main fuse or burn the windings open.

If one or two coils are burned out and it is necessary to run the motor, this can be accomplished in two ways—first, by putting in new coils; second, by getting the old coils out. A new coil may be put in two ways. If the repairman has plenty of time, the other coils can be raised out of their slots, the burned coils removed and replaced with new ones. Where the windings in a motor are in poor condition, oil soaked or charred, this would probably result in cracking the insulation of the good coils. In this case both ends of the burned-out coils should be cut off and removed from the slot by pulling it out a wire at a time and a new coil laced in turn by turn, and the ends connected like the old coil.

When it is necessary to get the motor back in operation at once, the coil may be cut out entirely. This is done by cutting open both ends of the burned-out coil and removing it, as has just been described, and then connecting together the two wires that lead into and out of the burned-out coil if they are of the same group. Several damaged coils can be cut out in this way, and the motor will still operate, but it will take an excessive current in the phase from which the coils have been removed. If the voltage is lowered slightly, little harm will result. This method is recommended only in cases where it is necessary to keep the motor running, and should in no case be used as a permanent repair, but only until at a time when new coils can be inserted.

Operation and Characteristics.

It often happens that it is necessary to operate a two or three-phase motor with single phase power. In fact, some manufacturers send out a motor with a three-phase winding when a single phase motor is ordered. The only difference in operation being the starting characteristics, that is, a single phase motor needs some auxiliary apparatus for starting, as it has no inherent starting torque.

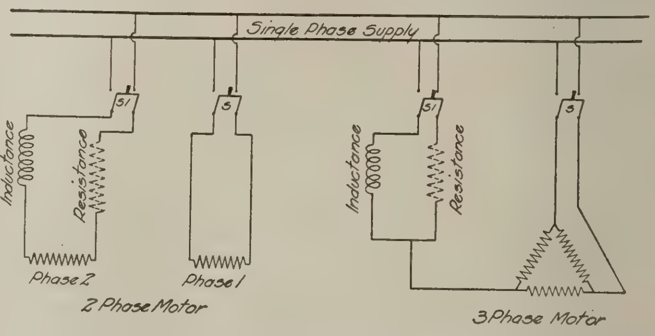

Fig. 17. Connections for Starting Two- and Three-Phase Motors From a Single-Phase Supply.

The diagram shown in Fig. 17 shows the connections that are used to start a two or three-phase motor on single phase current. The motors, either two or three phase, have two of the leads connected through the running switch "S" to the single phase supply wire; the other leads are connected through the resistance and induction coils to the starting switch S-1, which in both cases should be opened after the motor is up to speed. The resistance and inductance coils change the phase position of the current in the different phase windings, thus producing a rotating field which is necessary for the motor to be self-starting.

Repulsion Motor.

Another form of induction motor is in quite common use, because of its series of motor characteristics on starting. This is known as the repulsion type of induction motor. The rotor winding is of the concentrated form; in fact, the rotor is similar to the rotor of the direct current motor, and is provided with an armature. If the magnetic fields are excited by an alternating current, that portion of the armature windings which is perpendicular to the flux of the alternating field acts as a transformer winding and has a voltage induced in it, and if brushes were placed so as to commutate these coils an alternating current would be produced.

If a pair of short circuited brushes is so placed as to commutate the coils which lie about one-quarter of a pole arc from the mid pole position, the transformer windings will cause a current to flow through the brushes and through the coils which lie under the field poles. This has a motor effect which causes the induction motor to start. The armature may have two sets of brushes, one known as the compensating brushes, and the other as the energy brushes. These are short circuited and set at a determined angular relation with the stator windings, the two sets of brushes being placed 90 electrical degrees from one another. If the position of these brushes is shifted, the speed of the motor can be increased or decreased. After the motor is started, the brushes can be removed, and it will continue to operate as an induction motor if so desired.

We have now quite fully covered the different methods of winding and induction motor, but it should be remembered that there are other characteristics that govern the operation of an induction motor besides the windings. If any deviation is made from the conditions for which the motor is designed, the effects will be about as shown in the condensed table given below. Obviously the motor should be operated as it was designed to be, if the best running characteristics are to be obtained:

Conditions different From design.	Power Factor.	Torque.	Slip or speed change.
High Voltage	Decreased	Increased	Decreased
Low Voltage	Increased	Decreased	Increased
High Frequency	Increased	Decreased	Unchanged
Low Frequency	Decreased	Increased	Unchanged

The Railroad Electricians' Club

Railroad Electrician's Club of Chicago

The May meeting of the club was one of the most interesting and best attended meetings of the year. Mr. R. C. Lanphier, general manager of the Sangamo Electric Co., gave an excellent talk on the "Principles of Operation and the Construction of the Ampere Hour Meter."

The Ampere Hour Meter

Mr. Lanphier told briefly of the history of the development of the ampere hour meter and pointed out that the first Edison electro-chemical or electrolytic house meters for metering direct current circuits were really ampere hour meters, for the amount of metal deposited on the cathode depended on how many ampere hours current passed through the meter. These plates were subsequently weighed at the office and the customer billed accordingly.

It was in 1888 that the first mercury meter was built. The mercury cup was made of plaster paris and a revolving copper disc floated in the mercury was mounted between magnet poles. This meter was used in large central station work, tramways, etc., in England but was subsequently abandoned with the development of the wound armature type meter.

In 1900 the mercury type meters were first made in this country and a few were installed in connection with stand-by batteries. The design of the meter was rather crude, however, and it was so unsatisfactory that it was abandoned.

The first Sangamo mercury type meter was built in 1905 and in 1908 an ampere hour meter of the mercury type was first constructed at the request of Mr. Ernest Lunn, then battery engineer of the Commonwealth Edison Co., of Chicago. In this first meter the revolving motor disc was geared to a large dial hand, which indicated the number of ampere hours charge or discharge, the hand revolving in a clockwise direction on discharge and in the reverse direction on charge. A re-set device made it possible to set the hand ahead 10 or 15 per cent of the ampere hours discharge so that when the meter hand got back to the zero position it would make a contact which would trip a circuit breaker.

The Differential Shunt Meter.

The next development was to take care of this necessary setting ahead of the hand automatically. This was done first by employing a double shunt so that the current would pass through one shunt on charge and the other shunt on discharge. The design was such that the meter would run slower on charge than it would on discharge by any desired percentage and a slide wire adjustment made it possible to set this percentage of overcharge to any desired value.

Duplex Train Meter.

Another development about the same time was made in the duplex train meter. This meter consisted simply of a double row of indicating dials, one to indicate total charge, and the other to indicate total discharge. There were no contacts or automatic features about this meter, both dials recorded true ampere hours so it was only used as a check instrument.

The Resistor Type Meter.

The differential shunt type meter automatically provided for a suitable overcharge but this meter could not be used in connection with axle lighting systems because of the fact that the generator would charge the batteries and light the lights at the same time and the meter would refuse to give anything like a correct reading. This situation led to the development of the resistor type meter which was described in our June, 1914, issue. A resistor element consisting of a pivoted copper bar immersed in mercury and mounted beneath the magnet poles of the meter automatically provides that the meter will run slower on charge than on discharge so as to provide any desired percentage of overcharge.

Meter Troubles.

Mr. Lanphier gave a very interesting talk on the difficulties which have been overcome in perfecting the ampere hour meter to its present state of refinement. He said that one of the most troublesome features was the very peculiar behavior of mercury. It has a great faculty of amalgamating with such metals as copper, lead, etc., and tends to form a dross or solid substance which prevents the meter from recording correctly. There is no amalgamation with nickel, however, so all parts within the meter chamber are heavily nickel plated.

He referred to the fact that in many of the earlier ampere hour meters employed in car lighting service the meters were found to get badly out of adjustment. In practically every case this was due to the meter having been overheated. Car lighting men well know how hot it frequently gets in a regular locker, so it is not surprising that the meters become heated. This, however, caused the shellac-mica composition from which the early meter chambers were made, to soften and the meter shaft got out of alignment and would bind the rotating shaft. The present meters, however, are all made of Bakelite composition, which will stand a temperature of 400 deg. F. without softening, so troubles from this source are now entirely eliminated.

Mr. Lanphier showed a large number of slides of various features about the meter, one of which illustrated an important development in the ink well mercury chamber. It is now practically impossible for any mercury whatever to get out of the chamber, regardless of how the meter is tipped upside down or shaken, etc., since the shaft goes through a tube instead of the jewel at the top of the chamber.

Another difficulty found in some classes of car lighting service, particularly in straight storage service, is that the battery is charged at a very high rate and discharged at a very low rate, often being charged at over 100 amperes and discharge as low as 2 or 3 amperes.

Mr. Lanphier stated that they are now building a meter for this service in which a thermo-couple is provided which entirely overcomes the friction of the meter and allows it to record even the slightest discharge. As a matter of fact, this thermo-couple will, in most cases, be set so that the meter will creep forward a little bit all the time and this will compensate for much of the battery leakage current and will keep the meter in step with the battery whether the battery is in constant service or the car is standing idle for a long time.

In closing his talk, Mr. Lanphier stated that the mercury type meters are now built with very high accuracy and called attention to the fact that Sangamo mercury meters of the watt meter type are used in such buildings as the Singer, Woolworth, the new Equitable Life, the Ford Motor plant, for metering the current of Niagara, etc., and are used by a great number of the Edison companies. He also pointed out that the distant dial feature was employed in the Equitable Building where 30,000 amperes current at various points in the building were all indicated on 35 dials mounted on 2 panels in the switchboard room. An interesting feature of one installation was a combination of shunts and automatic switching devices so that a current varying from 30 to 30,000 amperes could be very accurately recorded at all ranges. He also showed a picture of the big shunt higher than a man which is used for measuring the 60,000 amperes for the Aluminum Company at Niagara. An ordinary 10 ampere meter is used in connection with this shunt with a ratio of 6,000 to 1.

Maintenance of Ampere Hour Meters.

Mr. Lanphier stated that the meters should be checked after the first month's operation in order to make sure that they are operating satisfactorily. It is rather a simple matter to check the meter for it is only necessary to pass a known charge or discharge current through it and count the number of seconds per 10 revolutions, from which the accuracy of the meter can be easily figured. He said that railroads should provide means for checking all meters at least once a year. It may be necessary to clean out the mercury if the meter runs abnormally slow, for mercury may collect copper, which will form in a dross on the surface and impede the meter disc. Only absolutely pure mercury should be used in filling the meter and he recommended that this be obtained from the manufacturer.

Questions

Battery Efficiency.

"How do you know what battery efficiency to assume; does not this vary with rate of charge, etc.?"

Mr. Lanphier stated that battery ampere hour efficiency does, of course, vary with the rate of charge and also with the amount of use which the battery receives, etc. He stated that it was the opinion of some of the best car lighting engineers that an overcharge of 25 per cent of the ampere hours discharge was ample. He stated that all meters shipped from the factory were set for this value of overcharge unless otherwise specified. He pointed out, however, that the resistor element makes it possible to set the meter for a 30 per cent overcharge. He stated that even though the meter setting was a little too high the amount of overcharge in ampere hours would be very low.

Graphic Ampere Hour Meter.

"How long will a graphic ampere hour meter run without attention?"

Mr. Lanphier stated that the chart of the meter is good for three months, and if the clock is wound once a week the meter will give a continuous record of the operation over this entire period.

Operation of the Resistor on Low Current.

"How will the variable resistor operate if the current reverses from charge to discharge at a low current value?"

Mr. Lanphier stated that the resistor element will operate on a current as low as 2 amperes in the external circuit. He stated that although discharge currents lower than this might be experienced that the current on charge, particularly at the start is invariably much higher than this, so there should be no question about the resistor element throwing over from a discharge to a charge position.

Meter Out of Step.

"What do you do when it is found that the meter is out of step with the battery?"

Mr. Lanphier stated that the meter should be checked at half speed and full speed and if the difficulty was not found here to look to the battery, for grounds will discharge the battery and throw it out of step with the meter.

Friction Clutch.

"Suppose the meter hand binds in some way; will it damage the meter?"

There is a friction clutch on the meter dial hand which allows the hand to slip if it binds and also makes it possible to reset the hand.

Edison Storage Battery Questions.

Continued from last month

Removing Connectors.

Q. 14. How can the connectors be removed?

Ans. 14. A small hand tool is provided for pulling off the connectors from the tapered posts. This acts very much as a pulley puller, the threaded bolt bearing down upon the post while two fingers grip the connector and pull it off as the bolt is screwed down.

Locating Poor Connection.

Q. 15. If the terminal posts or inside of connector are dirty this will cause a poor contact at the connector. How can such trouble be located?

Ans. 15. This will cause poor contact with the connector, therefore, a comparatively high resistance will be offered to the flow of current at this point. When the battery is on charge or discharge, with current flowing, this will cause heat to be generated at the point of poor contact and the connector will get hot and can be easily located by the inspector.

Nickel Plating of Parts.

Q. 16. Why are all parts of the Edison battery nickel plated?

Ans. 16. All of the battery is heavily nickel plated so as to prevent the steel from rusting. A novel process is employed in treating the nickel plated parts, for after the iron has been plated with a heavy coat of nickel all parts are baked at a very high temperature in an atmosphere of hydrogen to prevent oxidation. The high temperature anneals the steel and fuses the surfaces of the nickel plating and the steel so as to avoid all tendency for the plating to peel.

Flushing the Battery.

Q. 17. In the "H" type Edison cells how much space is left for electrolyte above the top of the plates? What will happen if the cells are filled too full when being flushed? How can this be prevented?

Ans. 17. There is sufficient space left for filling with electrolyte above the top of the plates. An automatic cell filler is furnished by the battery manufacturer which rings a bell when the cell has been filled to the proper point. If the cell is filled too full in flushing, the solution is apt to bubble out on gassing and cause grounds. This can be prevented by using the automatic cell filler and shutting off the water when the bell rings.

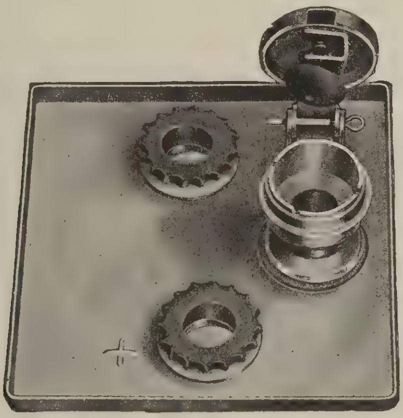

Fig. 9. Filling Cap and Gas Vent of Edison Battery. Notice Little Rubber Hemisphere Which Acts as a Valve.

Filling Cap and Gas Vent.

Q. 18. How is the filling cap constructed? Why is the gas vent constructed like a valve?

Ans. 18. The filling cap and gas vent are clearly shown in Fig. 9. On the under side of the cover is supported a little rubber hemisphere which, when the cover is closed, loosely rests on the valve seat and seals the cell. As gas is generated in battery action, this will force upward the light rubber valve and allow the gas to escape through the opening in the cap. This rubber valve seems to have the effect of removing most of the solution carried off in gasing and returns it back into the cell. This gas vent is constructed like a valve so as to prevent the ingress of carbonic acid gas from the outside which would combine with the caustic potash to form potassium carbonate, which would be inert as electrolyte.

Bulging of Cans.

Q. 19. What causes the cans or cell containers to bulge?

Ans. 19. If the cells are bulged uniformly all over it indicates that the gas vent has been clogged and the gas generated on charge has been unable to escape. This would soon be generated in sufficient amount to cause a high pressure and bulge the can. On the other hand, however, if the bulging is entirely at the top of the can it indicates that it was caused by a gas explosion, either due to a loose connection or some other spark or fire. This may not necessarily have been within the cell itself, as the explosion might be transferred from the outside through the gas vent provided the battery were gasing freely at the time. This does not disable the cell electrically so there is no need for repairs.

Effect of Extreme Cold.

Q. 20. What effect does extremely cold weather have on battery voltage, and what temperature does it take to freeze the electrolyte solid?

Ans. 20. If the battery is allowed to get cold the voltage and capacity may be seriously impaired temporarily, but normal conditions are restored when the battery again becomes warm. If the temperature of the battery be allowed to go as low as 25 degrees below zero or thereabouts, the electrolyte will freeze, but this has no deleterious effect upon the battery, except to temporarily affect the terminal voltage.

Q. 21. What practical means have railroads,using the Edison battery, employed for preventing battery failure in extremely cold weather?

Ans. 21. One railroad in Canada considered placing a small steam coil in the battery box to prevent the battery temperature from getting too low in extremely cold weather, but after some experimenting it was found that with a battery box properly built the battery would be kept warm enough so that even the severest weather did not cause a failure, so they removed coils.

When the car is allowed to stand in the yards for a long time with no current flowing through the battery, temperature may get down to a point where the battery cannot deliver its full voltage. In such cases, however, if a few lights are turned on in the coach yard for a half hour or so before the car pulls into the station, the heating effect of this current flowing through the battery will gradually raise the temperature a few degrees until the battery is able to deliver its full normal voltage. At such low temperatures the resistance of the battery increases considerably so that the heating effect of even a few amperes is much greater at this time than it would be under normal conditions when the battery resistance is low and the battery delivering normal voltage.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 41

Gould Simplex System

Although the Gould Simplex System has been described in an earlier lesson of this course, we feel that this equipment is of such importance to car lighting men that it should be described to even further detail than it was at that time and that the subjects of installation, dismantling, adjustment and inspection of this equipment should be fully discussed.

Description of the Generator.

The generator is a simple four-pole shunt machine driven from the car axle by means of a belt, as usual. Four brushes are employed, commutating at the four neutral points on the commutator the two positive brushes and the two negative brushes are connected in parallel so that if a single brush failure should occur it would not prevent the generator from delivering current. These brushes are mounted rigidly on a Bakelite ring, which in turn is bolted to the commutator end housing and all are removed with the end housing. A large hand hole with wing nuts is provided on each side of the generator so that all four brushes may be easily inspected and replaced by simply removing the cover. This cover is provided with a felt washer which is moisture and dust proof.

The "BB" generator is equipped with ball bearings and a special pipe with thumb screw cap is provided in the casing so that grease may be squirted from a grease gun into each ball bearing. The leads to the generator brushes and positive field are brought to a terminal block in the top casing of the commutator end of the generator and the pole changer is mounted on the under side of this terminal block; the negative field lead is brought out of the machine and connects to the switchboard wiring. The terminal block and pole changer can be taken off as one piece by unscrewing four nuts, and when the block is replaced, a moisture and dust proof washer seals the casing at this point.

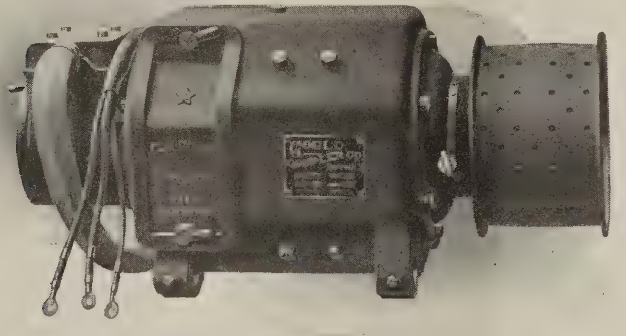

Fig. 204. View of the Gould Type BB Generator Equipped with Ball Bearings.

The Pole Changer.

It is well known that if the direction of rotation of a generator be reversed, and the generator fields be maintained the same, the generator will deliver polarity in the opposite direction; that is, the positive brush would then become a negative brush, and the negative brush a positive brush, etc. Therefore, a mechanical pole changer is provided so that proper polarity of the external circuit of the generator be always maintained whether the car be running in a forward or backward direction.

This pole changer is a very ingenous device and although a case of trouble at this point is exceedingly rare, we feel that car lighting men will be sufficeintly interested to warrant us in describing it in detail.

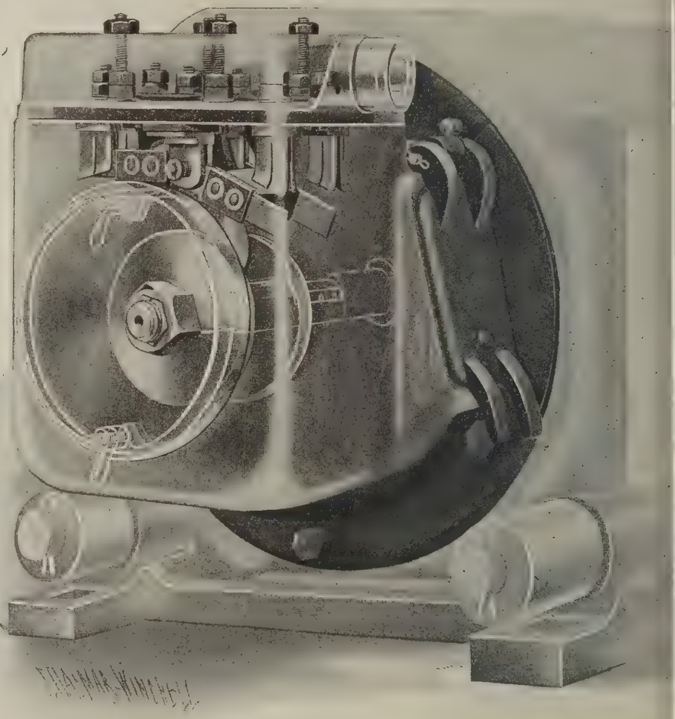

Fig. 206. Phantom View of the Pole Changer with the Armature Rotating in a Clockwise Direction, the Trip Is Just About to Throw the Pole Changing Switch so as to Reverse Connections.

The moving picture views of Fig. 205 show the operation of the device. A cast iron trip carrier, consisting of two discs with spacing rods between, is mounted on the commutator end of the armature shaft, as shown in Fig. 206, and a trip is pivotally mounted between the two discs. A double pole double throw switch is mounted directly over this trip carrier, as shown in Fig. 206, the connections of this double throw switch being shown in Fig. 209.

When the direction of generator rotation is reversed, it will develop reversed polarity; that is, the positive generator brush will then become negative and the negative positive. When the direction of car motion is reversed, however, the double throw switch will automatically be thrown from contact at the "A" position so as to make contact on the "B" side of the switch and since the generator negative brush, as shown in the diagram, has now become positive, due

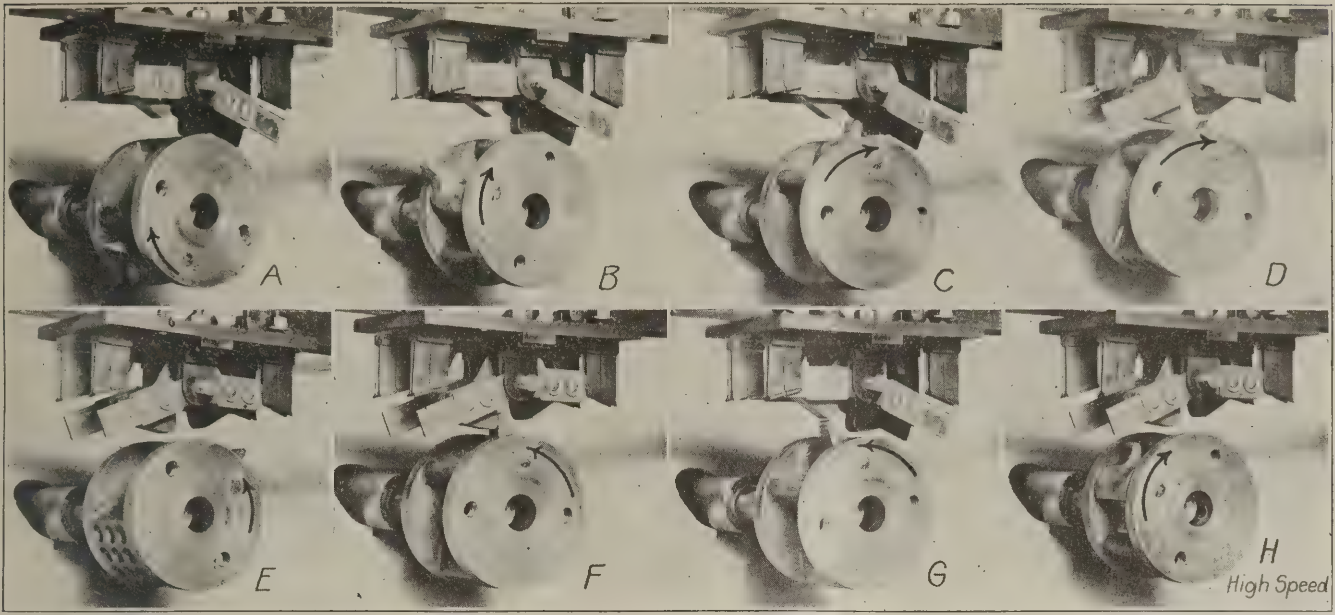

Fig. 205. "Movie" of a Pole Changer in Action; the Trip Carrier and Reversing Switch Are Mounted on Dummy Supports for Photographing. Figs. "A, B, C, D" Show the Various Steps of the Pole Changer Action in Throwing the Reversing Switch. The Armature Is Revolving in the Direction as Shown. In "A" the Trip Hangs Evenly Balanced at the Bottom, in "B" it has been Carried Upward but the Right Hand End of the Trip Striking the Shaft Tilts it Slightly as Shown. In "C" the Trip Is Engaging with the Projecting Lug at the Rear of the Switch on the Right Side. In "D" the Trip has Thrown Over the Reversing Switch and Passes the Projecting Lug of the Switch.

Views E, F and G Show the Pole Changer Operation when the Direction of Motion Is Reversed, as Shown. In "E" the Tip of the Trip Is Shown Tilted, the Left Hand End Then Bearing on the Shaft. In "F" the Trip has Just Engaged the Front Projecting Lug at the Left Side of the Switch and in "G" the Trip has Just Thrown the Switch and Trip Is Passing the Projecting Lug. In "H" the Trip Is Shown Evenly Balanced by the Centrifical Force when Operating at High Speed. The Trip Remains in This Position Without Any Tilt Whatever when Operating at a Speed of Above 4 Miles per Hour.

to the reversal of rotation, the rear blades of the switch will then have become negative and the front blades have become positive. With the switch thrown over to the "B" position by the pole changer, however, the front positive blade then makes contact with the positive clip and the rear blade makes contact with the negative clip of the battery circuit, this being accomplished by the cross connection in the switch, as shown. Accordingly, correct polarity will always be presented at the switchboard terminals regardless of the direction of car motion.

The Trip Mechanism.

The trip mechanism which throws over this reversing switch, however, is the important and interesting part of this pole changer. It consists simply of a double wing-shaped trip which is mounted in the carrier so that it is free to swing until one end strikes the shaft. It should be noted, however, that the right wing projects from the rear end of the trip, while the left wing projects from the front end of the trip.

To explain the operation of this device, let us follow the moving picture diagram of Fig. 205. We will assume that the car stopped so that the trip hangs in the "A" position and that the car has just started to move and the generator begins to revolve in the direction of the arrow, as shown. The trip, on starting, hangs evenly balanced on both sides since the center of gravity of the weight is below the center of support. As the armature slowly revolves in a right hand or clockwise direction, this trip is carried upward and remains in a horizontal position until the right hand end comes in contact with the shaft, meanwhile the left hand end projects outward, as shown in position "B." As the trip is carried up farther and reaches the top, as shown in position "C," the top forward wing projecting outward then engages a projecting lug at the rear on the right hand side of the double throw switch. Further motion of the generator in the right hand direction then causes this wing of the trip to

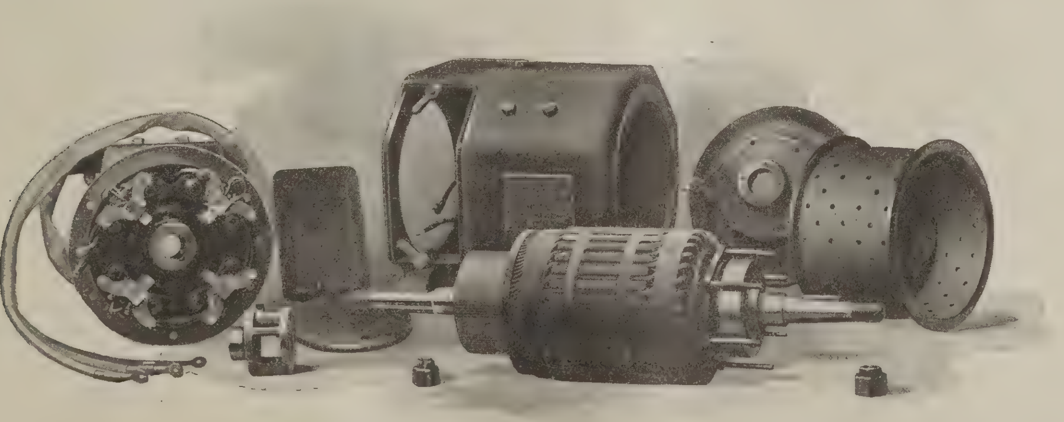

Fig. 207. The Type "BB" Generator Dismantled Showing Brushes Mounted on the End Housing at the Left. The Armature Is Shown Carrying the Pulley End Ball Bearing with Part of the Bearing Housing and Bolts.

force upward on the right hand side of the bridge until it trips the switch. As soon as the switch is tripped, a heavy spring toggle device completes the throw of the switch and causes the knife blades on the right hand side to be forced up solid into switch clips above and holds the switch closed in this position until the direction of the car motion is again reversed.

Fig. 206 also shows the trip just about to throw over the double throw switch, the armature revolving in a clockwise direction. After having tripped the switch, the trip passed freely by the projecting lug, as in position "D," Fig. 205, and continues to do so with successive revolutions in that direction.

The positions E, F, G, Fig. 205, show the successive positions of the pole changer when the direction of car motion is reversed. The trip is carried upward on the right hand side of the carrier and the right end of the trip projects outward, the left end of the trip then bears on the shaft. When the trip reaches the top the projecting wing then engages the front projecting lug on the left side of the switch, as shown in position "F," and forces upward on this lug, tripping the switch and causing it to throw in the reverse direction, whereupon the trip then freely passes the lug with a clearance of about 1/16 in., as shown in position "G."

When the train gets up to a speed of about four miles an hour the centrifical force of the unbalanced weight of the trip will be sufficient to hold it in a balanced position at all points of its revolution, as shown in the view "H." At all speeds above four miles an hour, then, this little trip moves practically rigid with the revolving carrier, so there is no wear whatever on the tripping parts. The pole changer reversing switch is thrown on the first revolution of the armature in a reverse direction and this part of the equipment will then take no further part in the operation until the car movement again reverses.

Generator Suspension.

The generator suspension is of the link type and is provided with a tension spring takeup on each side. This suspension will be described in a later lesson in connection with a general discussion of various types of suspensions.

Automatic Switch.

As the train leaves the station and the generator speed gradually increases, the generator voltage will build up and when the train reaches a speed of about 12 miles per hour (with a 2 to 1 pulley ratio) the generator voltage will then have risen to approximately 32 volts.

It will be noted from the wiring diagram, Fig. 209, that the fine shunt winding of the automatic switch is connected directly across the terminals of the generator. The automatic switch is adjusted so that when the generator voltage rises to 32 volts the magnetic pull of the current flowing through this shunt winding will be sufficient to pull up the plunger of the switch. The method of adjusting the switch will be explained in next month's lesson.

The bridging piece at the lower end of the plunger of the automatic switch, as shown in the center of Fig. 210, consists of a brass bar at the center with auxiliary carbon contacts mounted at each end, so that as the plunger is pulled up, contact is first made at the carbons. These are spring supported and permit the plunger being drawn up further until the brass bridge makes a strong wiping contact with the two inclined laminated copper brushes at the bottom of the switch. All arcing, either in opening or closing the switch, then takes place between the carbons, so that the copper brushes are protected from burning.

After the switch closes, current from the generator then flows through the series coil, strongly reinforcing the magnetic pull on the switch plunger and holding the contacts firmly closed. The generator is then connected directly in parallel with the battery and lamps and the auto-switch will remain closed until the train speed decreases to such an extent that the generator voltage falls below that of the battery. When this occurs, there will be a reverse current flowing from the battery to the generator, tending to motor it, since the voltage of the generator is then below that of the battery. This reverse current flowing through the series coil of the automatic switch will generate a reverse magnetism in that coil, opposing the lifting magnetism of the shunt coil. The shunt coil alone would, of course, keep the switch closed

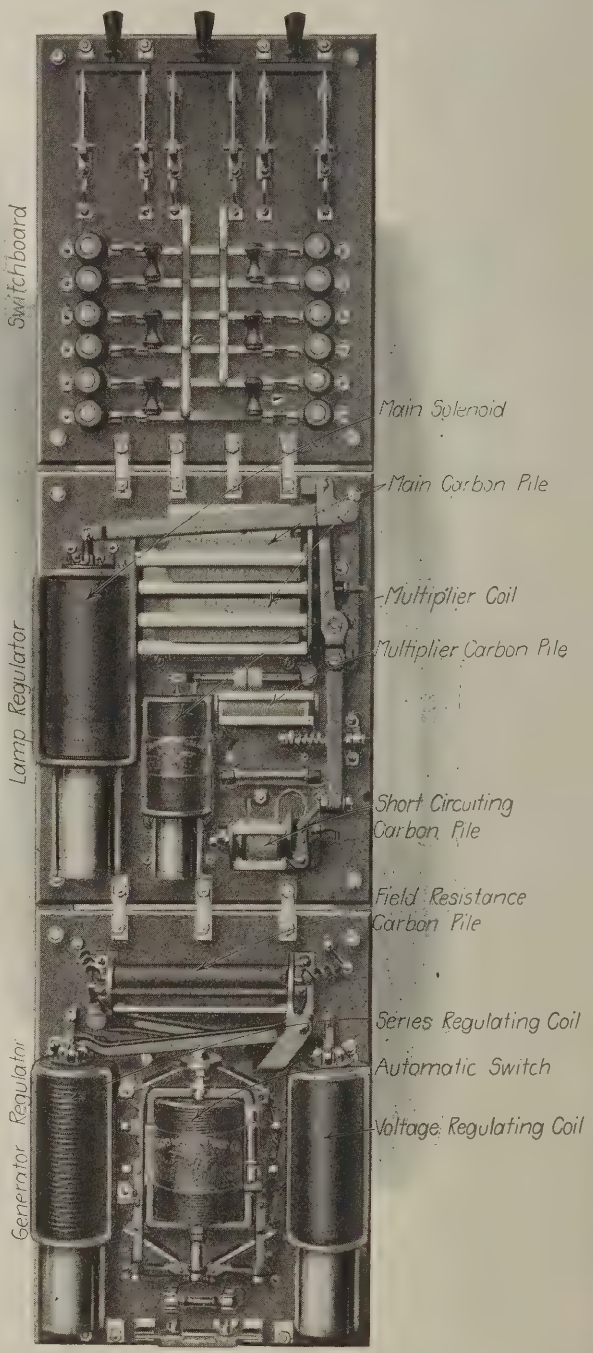

Fig. 208. Gould Simplex Panels as Mounted in a Locker.

until the generator voltage falls away to a very low value, but a slight decrease in generator voltage below that of the battery will cause a fairly heavy reverse current to flow from the battery through the series coil of the switch, and as this weakens the pull of the shunt coil, the switch will drop open as soon as the generator falls a volt or two below the battery. There will, of course, be a slight arcing as the switch opens, due to the breaking of this reverse generator current, but since the contact of the copper brushes opens before the carbon contacts of the switch, this arcing will take place entirely at the carbon contacts and should in no way injure the switch.

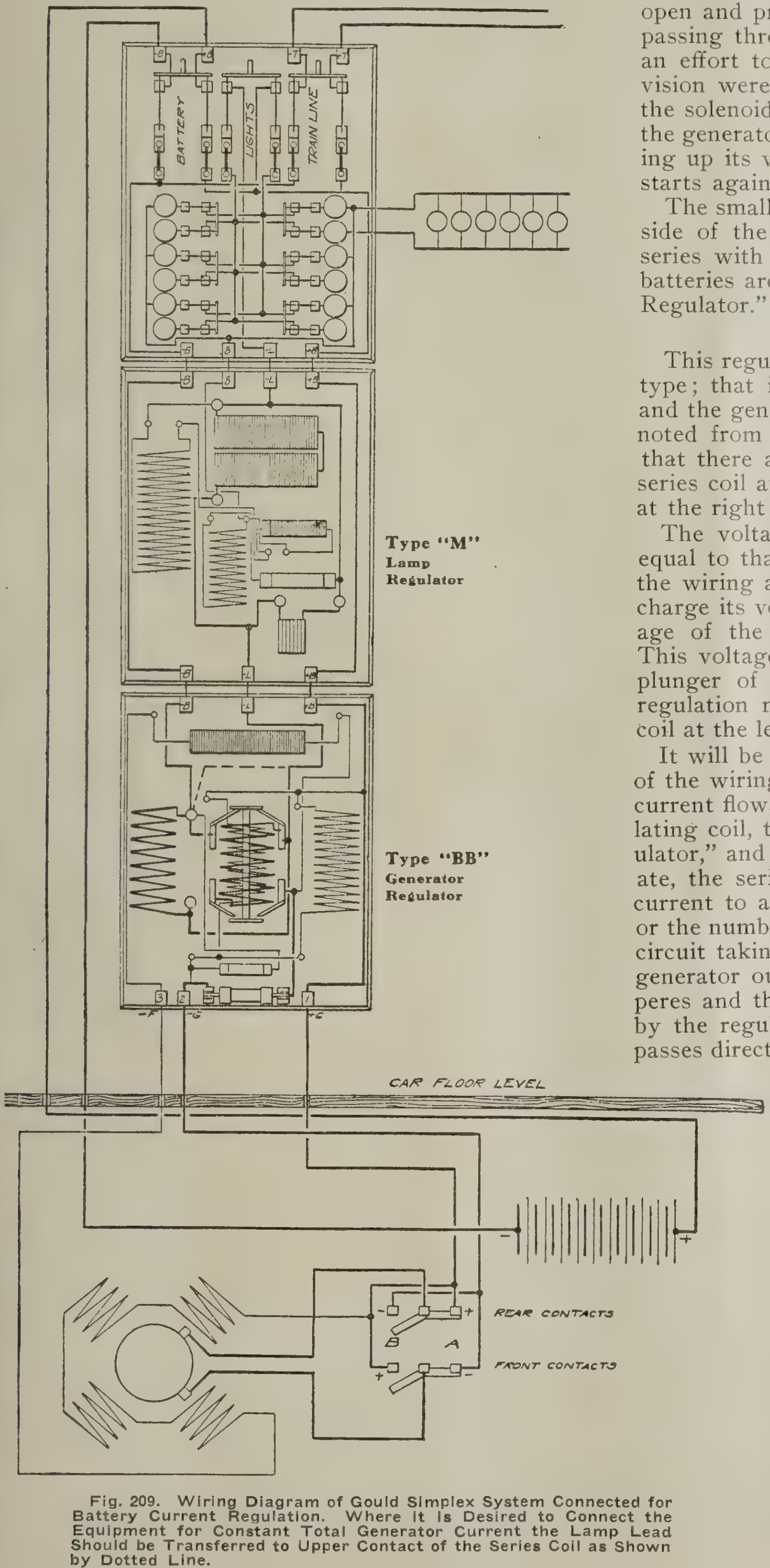

Fig. 209. Wiring Diagram of Gould Simplex System Connected for Battery Current Regulation. Where It Is Desired to Connect the Equipment for Constant Total Generator Current the Lamp Lead Should be Transferred to Upper Contact of the Series Coil as Shown by Dotted Line.

It will be noticed that there is another pair of long inclined copper brushes mounted on top of the switch. These contacts serve to short circuit the series coil of the generator regulator at the instant the switch drops open and prevents the lamp current from the battery passing through the coil on discharge, from exerting an effort to raise the solenoid plunger. If this provision were not made, a heavy lamp load would lift the solenoid plunger, thus increasing the resistance in the generator field circuit and preventing it from building up its voltage at cutting in speed when the train starts again, as will be explained later.

The small resistance unit mounted on the right hand side of the automatic switch frame is connected in series with the voltage regulating coil when Edison batteries are used, as explained under the "Generator Regulator."

Generator Regulator.

This regulator is of the combination current-voltage type; that is, it controls both the generator current and the generator voltage to normal value. It will be noted from the illustrations, Figs. 208, 209 and 210, that there are two separate regulating coils, a heavy series coil at the left side, and the fine shunt winding at the right side.

The voltage of the generator will always be just equal to that of the battery plus the voltage drop in the wiring and when the battery is in a low state of charge its voltage on charge will be low and the voltage of the generator will be correspondingly low. This voltage, then, will not be sufficient to raise the plunger of the shunt regulating coil, therefore, all regulation must be effected by the series regulating coil at the left side of the panel.

It will be noted from following out the connections of the wiring diagram, Fig. 209, that only the battery current flows through the windings of the series regulating coil, therefore, this is a "Battery Current Regulator," and so long as the voltage coil does not operate, the series coil will control the battery charging current to a constant value regardless of train speed or the number of lamps in use. For instance, if a lamp circuit taking 10 amperes current is switched on, the generator output will simply be increased by 10 amperes and the current to battery maintained constant by the regulator, since the 10 amperes lamp current passes direct from lamps to battery negative and takes no part in the regulation.

The equipment can easily be changed, however, so as to give constant generator output where the generator does not have sufficient capacity to carry both the lamp load and the battery current. This can be accomplished by transferring the connection of the lamp negative, as shown in the dotted line of Fig. 209.

The current adjustment of the series regulator is set at the factory and no further adjustment of either the series regulating coil or of the shunt voltage coil of the generator regulator should be necessary. There are no adjusting springs whatever, the weight of the plunger itself alone determines the current required to lift it. Where it is absolutely necessary to raise the current output this can be done by adding lead weights to the plunger of the series coil plunger.

Operation of the Current Regulator.

If the train speed rises suddenly, this will tend to increase the generator voltage, but this increase in generator voltage would cause a large rise in the current to the battery. Since this battery current flows through the series regulating coil, any increase in this current will pull up more strongly on its plunger. This plunger connects to one end of a lever, as shown in Fig. 210, and as the plunger rises, this lever decreases the pressure on a pile of carbon discs which are connected into the generator field circuit.

As explained in previous lessons, the resistance of a carbon pile decreases with an increase in pressure on the pile and the resistance increases with the decrease in that pressure. Therefore, as the train speed rises, the plunger of the series coil will be drawn upward into the coil farther and farther until the pressure on the carbon pile is decreased to such an extent and its resistance increased to such an extent that it will reduce the generator field current, which flows through the carbon pile, to a proper value so as to compensate for the rise in train speed and cut down the generator voltage to a normal value.

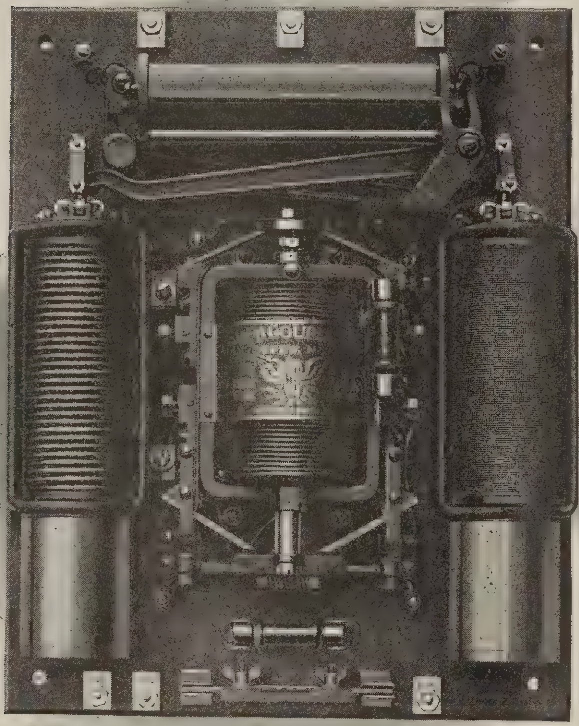

Fig. 210. Gould Simplex Generator Regulator Panel. The Series Regulating Coil Shown at the Left and the Voltage Regulating Coil Shown at the Right, the Carbon Pile at the Top and Automatic Switch in the Center.

In the same way, if the train speed decreases the generator voltage would tend to decrease, but the field current will be automatically increased by the series plunger lowering and increasing the pressure on the carbon pile. This will increase the current flowing through the generator fields and compensate for the reduction in generator speed and so maintain the generator voltage constant.

Operation of Voltage Regulator.

As the battery continues to charge, its voltage will gradually rise and, of course, the voltage of the generator will always be maintained slightly above that of the battery in order to force the charging current to flow from the generator to the battery.

It will be noted from the wiring diagram, Fig. 209, that the voltage regulating coil receives full generator voltage and the current through this coil will gradually increase as the battery voltage on charge rises. After the voltage of the generator and battery has risen to (40 volts for a 30-volt system with a lead battery, 80 volts for a 60-volt system with lead battery), the current flowing through the voltage regulating coil will then be sufficient to lift its plunger. The carbon pile shown at the top of Fig. 210 is really floating between two systems of levers, the lever of the series coil bearing at the right hand end of the pile and the lever from the voltage coil bearing at the left hand end of the pile. Either coil, or both, can then control the pressure on the carbon pile.

After the generator and battery voltage has risen to 40 volts, the voltage regulating coil will then assume complete control of the system and prevent the generator voltage from rising above that value. As the battery continues to charge, however, its voltage will tend to rise higher, but this is prevented by the action of the voltage coil, so the charging current to the battery will begin to taper off to a lower value. As soon as the taper begins, the current flowing through the series regulating coil will then no longer be able to hold up its plunger and this will gradually fall. The plunger of the voltage coil, however, automatically rises slightly to compensate for this, so as to keep the pressure on the carbon pile at a proper value. The generator then acts like any constant voltage machine, delivering the current required by the lamps and also providing a slight charge to the battery, the amount of charge depending upon the point to which the battery charge has tapered at that time.

There is a small resistance unit mounted on the right hand side of the automatic switch frame, Fig. 210. This resistance unit is to be inserted in series with the voltage regulating coil when Edison batteries are used. This increases the resistance of the voltage regulating coil circuit and and so requires a higher voltage to force the same amount of current through the coil and lift the plunger. With this resistance in series, the regulator controls the voltage at approximately 45 volts maximum for a 30-volt system and 90 volts for a 60-volt system.

Open Battery Circuit.

Another very important function of the voltage regulating coil is to prevent injury to the system in case the battery circuit is accidentally opened, such as would occur with a broken battery connector, a leaky tank, a blown battery fuse, etc.

Without the voltage control, under these conditions the generator voltage would be entirely uncontrolled and with a high train speed would mount to a very high voltage, burning out coils, etc. Even with an open battery circuit, however, the voltage regulating coil immediately assumes control of the system and prevents the generator from rising above normal value; moreover, while the train is above critical speed the current to the lamps will be maintained at normal voltage.

The lamp regulator and the subjects of maintenance, inspection, dismantling, etc., will be discussed next month.

Practical Stunts

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Test of Pole Magnetism

It sometimes happens that in changing a set of fields in an axle generator, one coil is reversed and while the machine may run after a fashion it will be so much out of magnetic balance that it will spark badly and give a much reduced output.

This seems at first thought to be a very simple matter, just remove the armature and excite the fields from a battery and test their polarity with a compass. The car lighting men who have tried this will know that it is impossible to use a compass in such a strong magnetic field because its polarity will generally be reversed which will cause incorrect indications. I have seen a horse-shoe magnet when used in place of a compass act in a most erratic manner. It was so affected by the magnetic field that the polarity of one leg was reversed so it had two north poles at the ends and one south pole at the yoke.

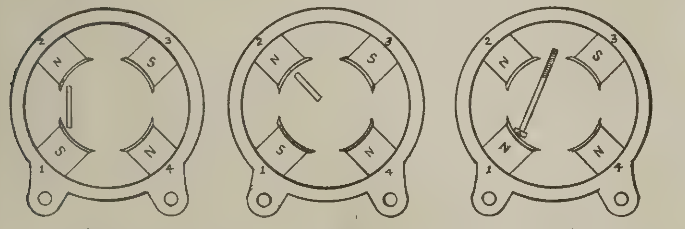


Fig. 1. Fig. 2. Fig. 3.

Diagrams Showing Simple Method of Testing Generator Polarity.

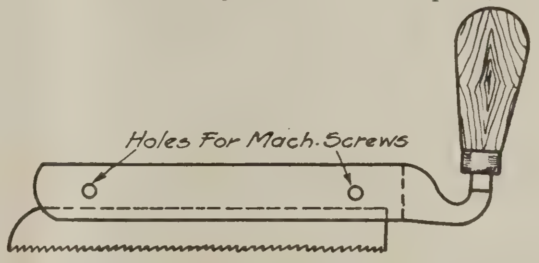
Here is a way to overcome this difficulty. With a piece of wrought iron about 4 in. long test each pair of poles as shown in Fig. 1. There should be a powerful attraction between adjacent poles, and if there is little or no attraction between two poles, try each magnet singly by applying a piece of wrought iron to each pole, as shown in Fig. 2. If any coil is not working properly this test will indicate the fault.

A good check on this test is made by taking a piece of wrought iron such as a ½ in. bolt approximately equal in length to the diameter of the armature, place one end in the center of this pole and hold the other in the center of the gap between the poles opposite as shown in Fig. 3. The direction in which the bolt is attracted will indicate the polarity of the pole in question. If the coil No. 1 is assumed to be reversed, this test shows that No. 1 and No. 3 are of opposite polarity for unlike poles attract. The other poles may be tried in the same way—E. C. Mielloret, L. I. R. R.

Tool for Undercutting Mica on Commutators

A tool similar to the one shown in the accompanying diagram is very handy for undercutting the mica on commutators. Two pieces of tool steel are bolted together, one piece being made with a projection, on which a wooden handle is fitted. Between these two pieces of steel a hack saw blade, which has been ground thin enough to work between the segments, is clamped. Rapid work can be done with this tool and it is heavy enough to be rigid.

J. E. Millard, Topeka, Kans.



A Simple Tool for Undercutting Mica on Commutators.

Loose Dynamo Pulleys

We have had a number of cases in which either the taper in the dynamo pulley or the taper on the shaft would allow the pulley to slip onto the shaft too far. This caused the pulley to become loose on the shaft when the retaining nut was perfectly tight.

An easy method to correct this difficulty is to apply a ⅞-in. washer between the pulley and the nut, which will force the pulley up onto the taper and at the same time not allow the nut to strike the shoulder.

Clyde Stewart, Santa Fe R. R., Chicago, Ill.

Charging 30-Volt Cars in Series

Take two receptacles and one plug, three pieces of wire (about No. 2 flexible) 12 inches long and connect the two receptacles in series with the plug.

By the use of this connector you can charge two 30-volt cars from any one yard receptacle using the same amount of current as you would to charge a single 30-volt car with portable rheostat.

Chas. W. T. Stuart, Philadelphia.

A Communication.

To The Editor: I have found Lesson No. 39, page No. 345, in regard to some peculiar things about battery grounds very interesting, and the explanation very clear.

Part of the theory is in line with our general ideas, but some of it might be open to further discussion or confirmation.

For example, in our central station 3-wire batteries we find most of the leaky cells and electrolysis on the positive side of the system, the theory being along the same lines that you have laid out; viz., that on the positive side current leakage over the insulators is in the proper direction to attack the outside of the linings of the tanks.

In regard to the sediment being transformed into lead sponge or peroxide, I think there might be room for some discussion as far as this definitely shows any particular condition. For example, this might result from other causes than leakage between the tank lining and ground, and I think you will find that the quality of the sediment varies in rubber jars, which would indicate that there might be some other explanation in at least some cases.—H. M. Beck, Operating Engineer, Electric Storage Battery Co.

With the Manufacturers

Railway Signal Receptacles.

Certain important improvements and simplifications in lamp receptacles for use in railway signal work are incorporated in two valuable specialties issuing from the factory of the Benjamin Electric Mfg. Co., 120-128 S. Sangamon St., Chicago.

With the abandonment of ancient methods of signaling and the adoption of the more reliable and flexible electric way, railway signal men have realized that successful operation of any system must depend upon the fitness of the component parts for the duty demanded of them. With the steady advance toward better and more efficient equipment, it is coming to pass that the electric signal accessory to get a hearing must have the quality of reliability and be particularly adapted to the special service.

Signal Socket with R. S. A. Binding Posts.

Signal Socket with Type "C" Binding Posts.

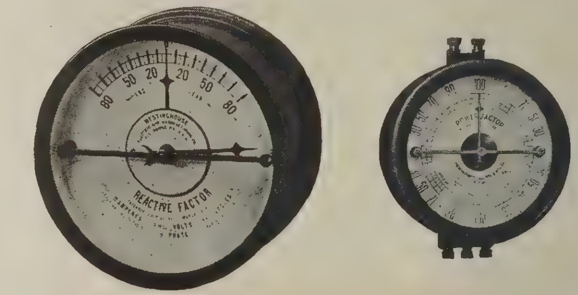
The Benjamin Company has clearly advanced a long step toward a standard type of receptacle for this work,—a service where the duty demand is unusually severe, and which is so closely associated with public safety and convenience.

Reactive Factor Meters.

Although instructed to keep the power factor of the circuits over which they have control as near unity as possible, switchboard attendants often maintain a power factor of one or two per cent less than unity as being good and do not try to improve it. But computation and tests show that a power factor of even only one or two per cent less than unity is not as good as it appears to many station attendants, especially on rotary converters. At 98½ per cent power factor the armature copper loss in the leading tap coils of a rotary is almost half again as much as at 100 per cent power factor. Under heavy load this is often enough to cause trouble in the tap coils. Also, the average heating in all the armature coils is about a quarter again as much at 98½ per cent power factor as at 100 per cent. The capacity of the rotary is therefore decreased considerably.

The measurements of "idle currents" is in general a recent development, wattmeters having been used recently so connected as to measure the idle volt-ampere, or "wattless component". The reactive factor meter, corresponds in its action to the power factor meter and bears the same relation to the latter, that the "wattless component meter" bears to the "wattmeter". This meter indicates the size of the angle of lag or lead instead of the cosine as in the power factor meter. Unity power factor is, therefore, indicated as zero reactive factor.

If instead of the power factor meter there is on the circuit a reactive factor meter, a condition of 98½ per cent power factor is indicated as 17½ reactive factor, and the attendant will be more on the alert and will be more apt to improve it.



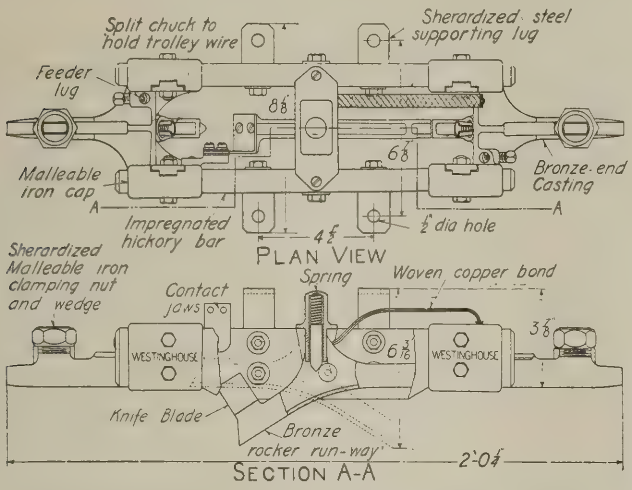
Reactive Factor Meter on Left and Power Factor Meter on Right.

Power factor and reactive factor are equal at the value 70.7 per cent. At higher power factor, the load conditions are more conspicuously indicated on the reactive factor scale. At lower power factors the reverse is true. Reactive factor meters are therefore recommended for use only on circuits operating normally at power factors close to unity and which never fall below 70 per cent.

The Westinghouse electric reactive factor meter, which has been recently introduced, operates on the rotating field principle, like their power factor meters, now on the market for several years. A rotating field is produced in angularly placed coils connected in shunt with the metered circuits, one for each phase of the system in the case of polyphase meters. In their field is provided a movable iron vane or armature, magnetized by a stationary coil whose current is proportional and in phase with that of the line current in one phase of the circuit. As the iron vane is attracted or repelled by the rotating field of the angularly placed coils, it takes up a position where the zero of the rotating field occurs at the same instant as zero of its own field. Thus its position indicates the phase angle between the voltage and current of the circuit. The reactive factor meter is then calibrated to read the sine of the angle indicated, while the power factor meter is calibrated to read the cosine.

Automatic Section Insulator.

A new section insulator has recently been patented by the Westinghouse Electric & Mfg. Co. These insulators are inserted in trolley wires where it is desirable to energize a section when the trolley passes onto it and to de-energize it when the trolley passes off. They are used extensively in mining installations where a branch is to be energized only when the locomotive is on that branch. Leakage losses and dangers of contact by persons passing under the trolley wire are thereby averted when the locomotive is not on the branch. Street railway companies sometimes use them in the same way.



Plan and Section View of Automatic Section Insulator.

The circuit is opened and closed by a switch blade mounted on a rocker that the trolley operates. In one position the blade connects with copper contactors. In the other there is no connection. A brass plunger pressing against a steel roller gives a position centering action and prevents the rocker from remaining in an intermediate position. There is no arching at the switch contact, because the rocker is always energized and the switch connection is always opened or closed while the trolley wheel is on the rocker.

Side bars of impregnated hickory take the stress. All metal parts are either sherardized or of bronze. Wedges are used to hold the trolley wire and an internally threaded chuck, like that used in the Westinghouse Cleveland splicer, supplements these. A flexible woven-copper bond carries current to the switch blade on the rocker.

These insulators are manufactured by the Westinghouse Electric & Mfg. Co. and are the same automatic insulators that have been manufactured by that company for some time past.

A Handy Volt Ammeter

weighs less than 3 lbs., size only 3x5x6 inches, can be furnished with 3 voltage and 3 ampere ranges. It is easily carried in hand or case—**the ideal instrument for inspectors.** Write for particulars and complete catalog of pocket, portable and switchboard Voltmeters, Ammeters and Voltmeters.

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The "Ironclad-Exide" Battery For Locomotive Headlights

Many railroads are considering the use of electric headlights for locomotives.

The Southern Pacific Railway Company have 946 locomotives equipped with electric headlights and "Ironclad-Exide" Batteries.

The characteristics of this battery make it particularly suited to the requirements of this class of work. It is rugged, has long life and can be operated for much longer periods without cleaning than any other type.

Our engineers have carefully studied this subject and will be glad to co-operate with you, furnishing you with any help or information you desire. Write our office nearest you.

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The ALEXA-LITE is the last word in efficient office lighting. Ask for details.

A Customer Says:

"The 400-watt lamps with large base came in today and we are now enjoying a perfect office light; no dark corners, no shadows, no eye strain. Like so many other good things common today, but unknown to a previous age, we don't see how we got along without it. Will certainly make use of more ALEXA-LITES when opportunity offers."

"DELTABESTON" Magnet Wire is insulated with pure asbestos

A simple test to prove that "Deltabeston" Magnet Wire is entirely indestructible under commercial conditions is to couple a piece of "Deltabeston" with ordinary magnet wire and subject to the same currents. You may completely destroy the cotton covered wire without affecting "Deltabeston."

Have your Old Motors, when burned out, rewound with "Deltabeston" Magnet Wire, and specify it when ordering new motors.

The largest electrical companies have adopted "Deltabeston" Wire for winding their motors. Just specify "Deltabeston" Magnet Wire and don't confuse it with any other asbestos covering.

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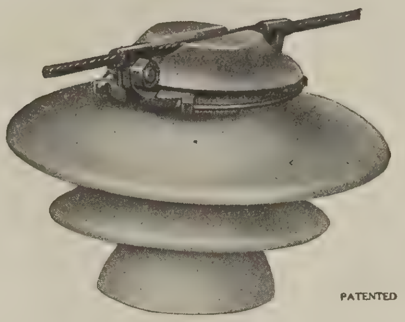

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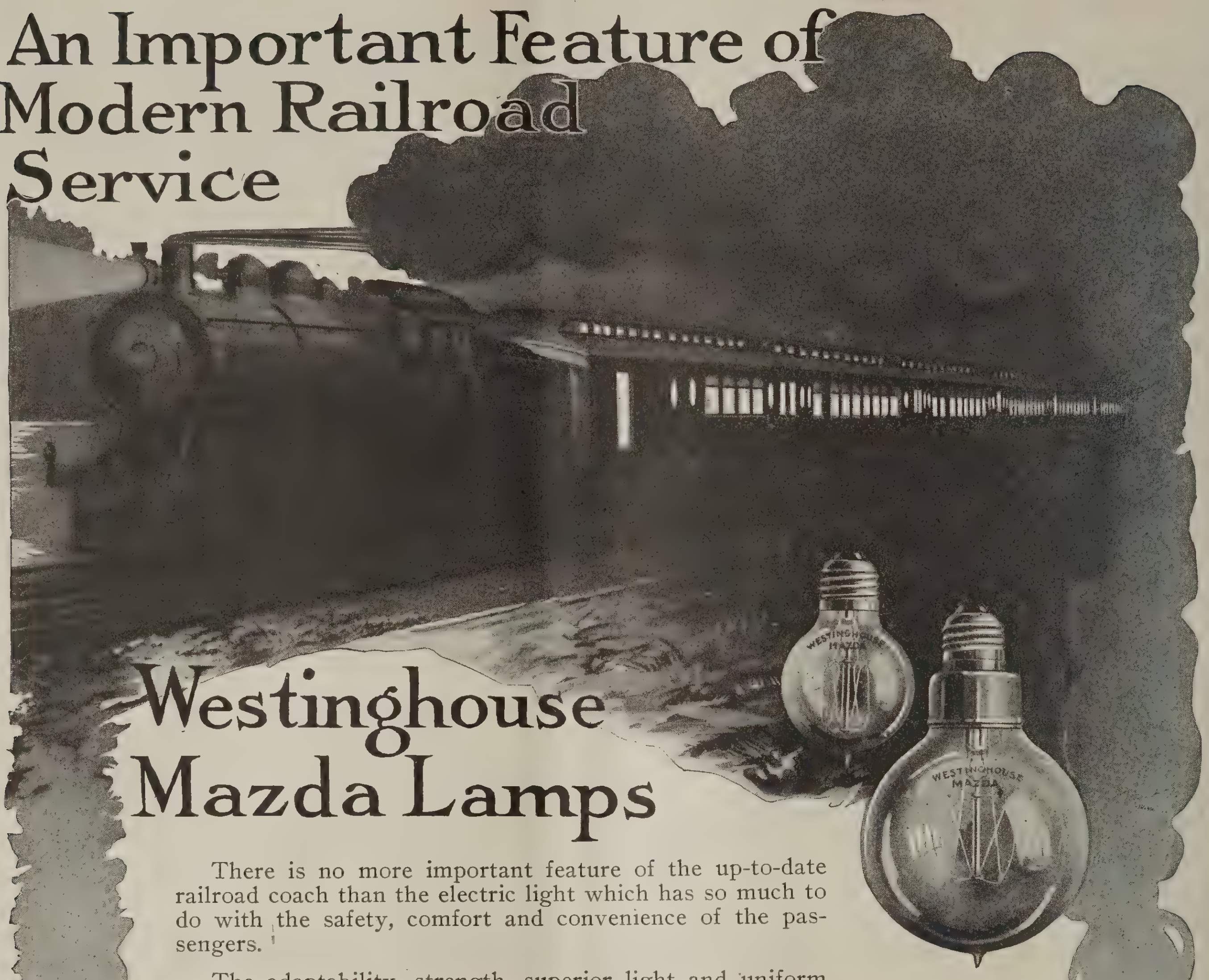

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The Pasted Plate Battery in Car Lighting Service

Pasted plates have never been used very extensively in electric car lighting service, although they have been thoroughly tried out in this service at various times by different railroads. That these trial installations have proved, for the most part, to be a failure, was undoubtedly due largely to the fact that in the early days car lighting service was rather severe on the battery. This was probably due both to the fact that the battery was frequently overcharged at high temperatures by the axle lighting equipment, and on the other hand was often allowed to stand in a discharged condition, causing sulphation of the plates. Even in head-end service, where the battery receives a certain amount of personal attention, the plante type plates were found to stand up better than the pasted type plates.

The successful operation of a great number of pasted type plate batteries in motor truck service, however, has demonstrated the fact that their failure in electric car lighting service was not due so much to the conditions of mechanical vibration as to the electrical treatment which the battery received, for there is no doubt that a battery mounted on a commercial motor truck receives more severe vibration than when mounted on a railroad passenger car.

With the present modern axle generator equipments employing the taper charge principle produced by constant voltage control, or those having the ampere hour meter control of battery charge, the severe conditions of overcharging are greatly reduced, if not eliminated entirely. Therefore, the pasted type plates should soon come into more general use for car lighting service, and under the improved operating conditions now existing should give reasonably long life.

It is interesting to note the attempt on the part of one battery manufacturer to produce a pasted type plate which will stand up in car lighting service. In another part of this issue is published an article describing a double positive type pasted plate and illustrations show the condition of the plates after 4½ years service on a buffet and parlor car with an axle equipment.

This is a novel type of construction and if the results as shown can be duplicated with a large number of batteries in all classes of service, this type of battery undoubtedly will have a future in car lighting service. However, it must be remembered that this is simply an experimental battery and one isolated case.

Some battery engineers will doubtless inquire, "Why not make the positive plate one thick plate instead of two thin plates spot welded together?" Since a space of about ⅛ in. is provided between the plates, this allows the electrolyte to easily enter and leave the active material on the inside surfaces. Whereas, if this same amount of active material were made into one solid plate the diffusion of the electrolyte to and from the active material at the center of the plate would necessarily take place more slowly and there might be a tendency for the active material at the center to become sulphated because of the fact that it was not worked sufficiently. In any event, the results of these tests seem to be so promising that a further investigation is undoubtedly warranted. Attention, however, should be called to the fact that under the existing conditions of the operation of modern types of axle equipments, wherein the severe conditions of overcharging are largely eliminated, the necessity for adopting a battery of the double plate type in order to withstand the conditions of this service are much less at the present time than they were five years ago when this battery was put into service. Moreover, it would seem that under the improved operating conditions an ordinary pasted type plate with a moderately heavy grid, well reinforced, should give satisfactory service and show long life.

Long life is one of the chief criterions of battery excellence in car lighting service and when it has been established that this may be obtained from pasted type plates, their other advantages of low cost and light weight will undoubtedly cause this type of a plate to come into very general use for railway car lighting service.

A. I. E. E. Annual Convention

Held at Deer Lodge, Maryland

At the 32nd Annual Convention of the American Institute of Electrical Engineers, held at Deer Lodge, June 29 to July 2, the session held on July 1 was devoted to papers on the construction and operation of third rail and overhead contact systems. The desirable features of different designs was given and the difficulties that have been met with in the different systems is given special attention. Cost data and construction and maintenance was very complete and will prove a valuable guide in future projects. Those portions of the papers which should prove of especial interest in the electrification of steam railroads are given in the review below.

J. V. B. Duer, assistant engineer Pennsylvania R. R. of Altoona, Pa., gave the details and cost of construction as observed and compiled from the 7 years' operation of the West Jersey & Seashore R. R. This railroad has about 132 miles of third rail, equivalent single track mileage and 20 miles of trolley track, which includes .91 miles of trolley track which overlaps the third rail. Substations are located approximately 10 miles apart and no third rail feeders are used. The substation boss voltage is now maintained at 700. Trains of from 2 to 7 cars are operated.

Third Rail and Trolley System. West Jersey & Seashore R. R.

Construction Details.

The third rail throughout is of the P. R. R. standard cross section and composition. The rails are in lengths of 33 ft., weight 100 lbs. per yard, and have a conductivity about equal to that of a copper rod of 1,200,000 cir. mil. area. Each rail joint is bonded with two copper ribbon bonds of 500,000 cir. mil. area each. The third rail end approaches are made of cast iron.

The third rail insulators used are of reconstructed granite or porcelain and are held in position by a metal centering cup which is secured in the tie by means of a lag screw. The rail rests on, but is not fastened to the insulator, thus preventing strain on the insulators when the ties are depressed, due to a passing train. The insulators are placed on ties 9 ft. 4 in. long spaced approximately 8 ft., or every fourth tie. An insulator of new design has recently been adopted, due to a change in the method of supporting the top protection boards. Fig. 1.)

The third rails were originally protected only at stations, 75 ft. on either side of road crossings, and in terminal yards. The bottom casting, attached to the rail by a hook bolt, supports the whole protection structure. (See Fig. 1.) A maple post attached to the bottom of the casting by a bolt, supports the top casting to which are bolted the ends of adjacent top protection boards of 2-in. plank.

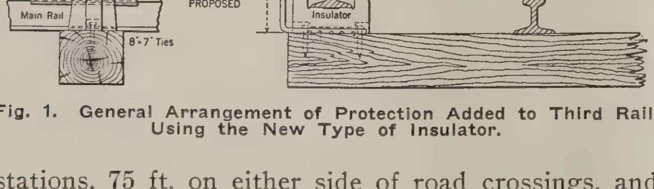


Fig. 1. General Arrangement of Protection Added to Third Rail, Using the New Type of Insulator.

During the early part of 1912, top protection was added to all unprotected rail. The board is supported by wrought iron brackets attached to the long ties carrying the insulators and adjacent boards are joined together by means of a wrought iron plate. Originally the wood was not treated in any way, but was given several coats of paint after installation. But in this latter installation they were given two coats of hot creosote.

A regular No. 4/0 grooved section trolley wire was used, supported by ⅜-in. galvanized steel stranded span wire at a height of 22 ft. above the track. Most of the supporting poles are of wood, though tubular steel poles are used to some extent. Experience has shown that stranded wire bonds give the least trouble. So little difficulty has been experienced with the third rail that it has not been found necessary to sectionalize it to any great extent.

Original Cost of Construction.

The original cost of construction for the third rail, including rail bonding, insulators, protection, etc., for the 131.73 miles of road was $557,636.00, making the cost per mile $4,235.00 The cost for 19.56 miles of trolley wire, including wire, poles, line material, lightning arresters, etc., was $80,500.00, or a cost of $4,120.00 per mile. The cost of 151.29 miles of track bonding was $102,659.00, or $678.50 per mile.

Maintenance Experience.

The third rail began to creep in the direction of traffic shortly after being placed in service, which resulted in straining the bond and breaking insulators. To overcome this difficulty the third rail was anchored to the ties at intervals from 1,000 to 1,500 ft. The splice bars were loosened and the joints oiled semiannually. The anchors gave some trouble by breaking down the insulation and it was found that the oiling of the joints was sufficient to prevent creeping, so the anchors were removed.

For overcoming sleet formation, special cars were fitted with calcium chloride tanks with means for heating same and distributing on the third rail while hot. These cars are hauled over the road by steam locomotives when sleet begins to form and have aided materially in reducing trouble from this source. The addition of top protection overcomes sleet formation in a great many cases but is of little use when a driving wind accompanies sleet forming weather.

Maintenance Costs.

The average cost per single track mile per year for the last 7 years for maintaing trolley, third rail and track bonding systems has been $490.25 for the trolleys; $81.74 for the third rail, and $25.84 for track bonding, which makes their respective cost 11.90, 1.93 and 3.7 per cent of the investment per mile.

The train detensions chargeable to contact systems in the year 1912 with 141.73 single track miles of third rail and 9.56 single track miles of trolley are as follows: The car miles per minute detension chargeable to third rail short circuits are 56,674; to third rail out of place, 1,161,809; to third rail protection out of place, 232,361; sleet on third rail, 11,886; to trolley wire trouble, 17,085.

Construction and Maintainance Costs of Overhead Contact Systems

This paper by Mr. Amberg, engineer for McHenry & Murray, New Haven, Conn., is written with special reference to the electrification of the N. Y., N. H. & H. R. R. between New York and New Haven, to the New York, Westchester & Boston R. R., and Hoosac Tunnel Section of the Boston & Maine R. R. The New Haven section covers the entire engine district comprising 75 route miles of 4 and 6 track main line, 6 route miles single track branch line, large freight yards, station sidings and industrial spurs. The N. Y., W. & B. R. R. section consists of 17½ route miles, of 4 and 2 track main line with yards and sidings. The B. & M. section consists of 8 route miles of double track with yards and sidings, including a tunnel section of 4.75 miles.

Catenary Systems.

Three distinct catenary systems have been installed on the New Haven and its allied lines, viz., double catenary, compound catenary and single catenary.

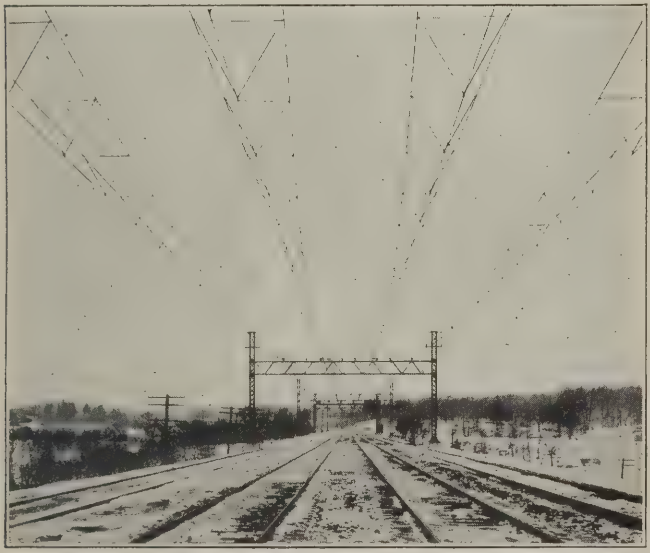


Fig. 1. Double Catenary Installed on Original New Haven Electrification Between Woodlawn and Stamford.

The double catenary was a pioneer installation applied to heavy trunk line traffic conditions. It was considered necessary to provide stiffness against winds to keep the trolley within reach of the locomotive pantographs. Two 9/16 in. steel messenger strands were used, to which triangular hangers were fastened, these supporting the copper trolley wire. This combination, however, was not adapted to high speed service and was readily changed to a flexible system by the addition of a steel trolley wire supported by clips from the proper conductor. The double catenary system has the advantage that if one messenger broke, the other would prevent the catenary from falling. Its disadvantages are that because of the two live messengers it is impossible to do work on bridge trusses, where these wires pass, without having the power cut off. Lightning trouble has bothered considerably with an insulated messenger wire, but this trouble has been reduced to a great extent by electrolytic lightning arresters.

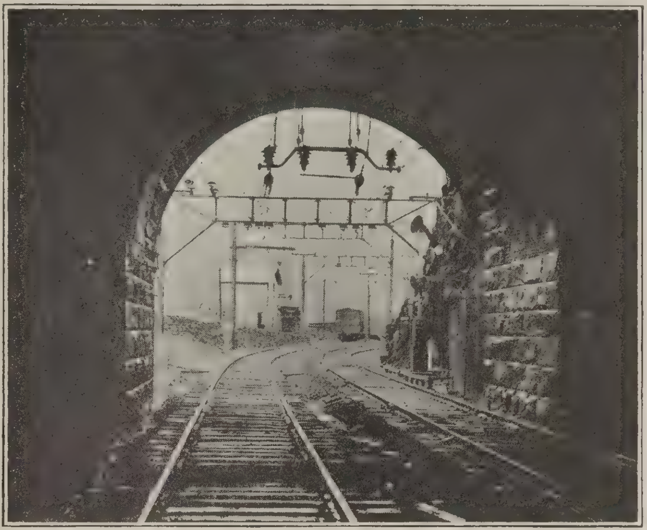


Fig. 2. Hoosac Tunnel Electrification, Showing Light Catenary Bridges and Double Insulation in Tunnel.

The compound catenary construction has a grounded messenger over each track which removes the live parts of the catenary from the trusses, eliminating lightning trouble and at the same time serves to keep the trolley wires nearly over the center of the track without the use of pull-off poles. On curves the "Murray" hanger is used. This is clamped to the messenger and is held at a suitable angle by the acting forces. Even on reversed curves no difficulty has been experienced in keeping the contact wire in its proper location. On curves above 2 deg. the temperature has an influence on the alignment of the contact wire, requiring the use of pull-off spans between bridges.

In the single catenary construction the insulators are attached to the under side of the trusses and the single catenary suspended from them. This also keeps the live wires of the catenary below the steel work and for tangent sections the bridges can be spaced 300 ft. This construction may be used for both main line and yard work and in yards the copper wire may be omitted for the reason that in the average yard the trolley wires have sufficient current carrying capacity, since several tracks are connected in multiple.

For future electrifications steel contact wire will doubtless be less used, for it rusts considerably; this

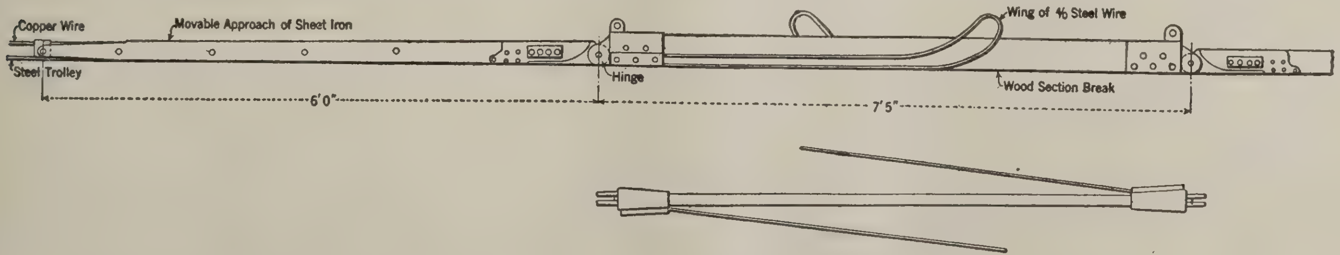


Fig. 3. Wood Section Break. The Flexible Wings Are Arranged to Prevent an Engine from Stalling at This Point.

rust is washed off by rain and drops off on the coaches and locomotives, making them unsightly and necessitating more frequent painting. Where locomotives are operated infrequently rust collection causes increased sparking and burning of pantograph shoes.

Mr. Amberg states that the insulators used on the New Haven electrification were all tested for 110,000 volts. Temperature strains in porcelain insulators should be given most careful consideration, especially in a dead end type and failure is most frequent where clearance between the locomotive stack and the insulator is restricted.

Supporting Structure.

There are three classes of supporting structures used—bridges, steel or wood with cross spans, and poles with brackets. The supporting structures on the New Haven and the N. Y., Westchester & Boston were designed not only to carry the catenary system, feeders and transmission lines, but also a signal over each track weighing 2,400 lbs. A bridge was the only structure which would fulfill these conditions.

On the New Haven electrification between Woodlawn and Stanford the bridges are designed so that all overturning moments were taken at the base, a feature which required large foundations. The bridges for the Harlem River branch and the main line between Stanford and New Haven were designed to take the moments resulting from stresses acting across the track in the corner connections between posts and truss. This construction is much lighter, as the foundations have only to resist the overturning moment along, and the shear across, the track.

It is necessary to sectionalize the contact system to locate trouble and to make repair with the least interference to operation. To disconnect a defective section quickly, automatic oil circuit breakers are used. The actual break and gap in the track catenaries can be made in different ways, and two different types are in use on the New Haven, the one rigid and the other flexible. The accompanying illustration (Fig. 8) shows a rigid type wood section insulator, which gives a simple construction but produces an undesirable hard stop for high speed operation. A movable approach wood section brake somewhat reduces the effect of the hard stop. Flexible wings shown at the wood section break prevent an engine from getting stalled at that point.

Mr. Amberg gives curves which show the cost of different types of catenaries on 2, 4 and 6 track sections at various curves. He also gives detailed cost data on the erection of the catenary. The cost of feeder and transmission lines varies from $20.00 to $50.00 per mile of wire and in large yards of regular layout the total cost can be as low as $3,000.00 per mile of single track, inclusive of sectionalization and feeders.

Construction, Maintenance and Cost of Overhead Contact System

In a paper under this title, Mr. F. Zogbaum, engineer of maintenance of New York, Westchester & Boston R. R., gave a general view of the problems involved in maintenance and cost of overhead contact systems of the catenary type. Mr. Zogbaum states that one of the most important matters pertaining to the maintenance of an overhead catenary system is the inspection of the contact wires and the transmission system. Although on some roads it has been found advisable to stagger the contact wire in order to get uniform wear on the pantograph, it has not been found necessary in this case. He calls attention to the swaying movement of the train, especially on curves.

This railroad consists of 54.26 miles of contact wire and 181.29 miles of transmission lines. The contact wire is suspended over 30 per cent curved track and 70 per cent tangent track, so that practically the only adjustment necessary is on 30 per cent of the road. Included in the catenary system are 6 sectionalizing or anchored bridges and 77 high tension oil circuit breakers, which are used for sectionalizing the high tension power.

The organization for maintenance of the catenary transmission system is headed by the engineer of maintenance, to whom the general electric foreman reports direct. The general electric foreman has under him one day foreman, one night foreman, five linemen and one assistant lineman. The day foreman, three linemen and assistant lineman cover the entire system and make repairs on practically all the apparatus except the contact system or transmission system. The night foreman and two linemen cover the entire line and use a work train in inspecting and repairing the contact system. The work train consists of one gasoline electric locomotive and work car. A platform is mounted on top of the locomotive and a large search light aids in making the repairs.

Operating Efficiency.

In 1913 there were 27,927 car miles operated per one pantograph failure. In 1914, 55,503 car miles operated per one pantograph failure, and for the three months ending March, 1915, the record was 64,799 car miles. Some of the causes of broken pantographs are wire off center, low joints on running rails on curves, overhead frog on deflector out of adjustment and loose leaves on contact wire. During the year of 1913 the total number of train miles operated was 879,000, power trouble caused 210 delays, totaling 2,170 minutes. Pantograph and contact wire trouble caused 17 delays with a total loss of 129 minutes. In 1914 the train miles operated were 878,000, the delays due to power trouble were reduced to 97 with a loss of 2,256 minutes. Fifteen delays due to pantograph and contact trouble caused a loss of 117 minutes. During the first three months of 1915 there were 217,000 train miles operated with no loss due to power trouble and one delay of two minutes' duration due to pantograph and contact wire trouble.

Mr. Zogbaum gives tables classifying the causes for delays during the period of 1913 to date.

This road has been especially free from insulator failures. Out of the total number of 2,339 insulators carrying the signal transmission lines, no insulator failures have occurred in three years' operation. Out of the 6,761 insulators carrying 11,000 volt lines, one contact line insulator failed in 1913, six contact and one transmission line insulators failed in 1914, and but one insulator failure on the transmission lines in 1915.

Wear.

The total wear on the contact wire to date has amounted to ⅛ in. in flat surface and on the under side of the grooved contact wire. At this rate it will not be necessary to remove the steel trolley wire for six or seven years at least.

The life of the pantograph varies from 1,000 miles in the winter, to well over 2,000 miles in the summer. The decreased life in the winter is due to the additional tension necessary on the upward motion of the pantograph on account of the raising in the contact wire caused by contraction. The total cost per car mile

July, 1914, was $.015 and for December, 1914, $.014. These figures include supervision, transmission and contact system, miscellaneous electric line expense, work train, etc.

Mr. Zogbaum gives a brief description of the rules and regulations which are enforced by the company to prevent accident to the employees resulting from working with so high a voltage.

Top Contact Unprotected Conductor Rail for 600-Volt Traction System

This is the title of a paper written by Charles H. Jones, assistant electrical engineer of the Metropolitan West Side Elevated R. R. of Chicago. This paper deals with the various factors which enter into the construction, operation and maintenance of top contact, unprotected third rail located to one side and above the coach line above the track rail on a heavy 600-volt direct current protection system using a gravity type collection division.

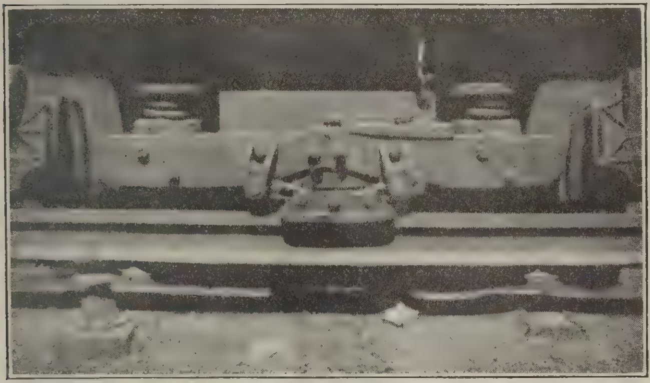


Fig. 1. Gravity Type Collection Shoe for 600 Volt Contact Rail Service.

The following elements were considered in this paper: Weight of rail, quality of rail, insulating and supporting, bonding and jointing, anchoring, special work required, method of connecting at crossings, cost of installation, and maintenance.

Weight of Rail.

At the present time the third rails weighing from 40 to 150 lbs. per yard have been in service. The light rail has been less satisfactory and recent practice has abandoned it for a heavier rail, except for yard purposes. The great advantage of heavy rail is that a large amount of conductivity can be installed for almost the same amount of labor charge as that required to install a light rail. If a paralleling feeder system is required, even with an extremely heavy rail, a medium weight rail from 80 to 100 lbs. will give more satisfactory results. Mr. Jones gives the useful life of a 40-lb. rail as 20 years; that of a 48 to 50 lb. rail as 26 or 27 years, and an 80-lb. rail installed 12 years shows a very small amount of wear to date.

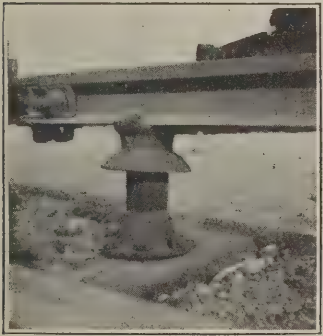


Fig. 5. Side Incline Approach. Fig. 2. Impregnated Wood Insulator. Base Casting Is the Same for All Lengths of Rail, But Length of Block and Top Castings Are Varied.

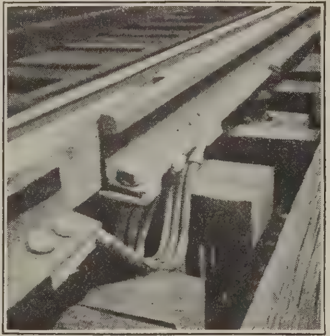


Fig. 3. Expansion Joint In Third Rail Makes Good Running Surface. Note Long Bonds Necessary to Bridge Gap.

The standard A. S. C. E. section is very satisfactory for rails weighing up to 80 lbs., but for those heavier than this a special section is perhaps advisable, which will throw more metal into the contact surface.

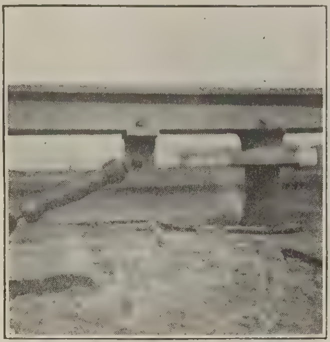


Fig. 4. Method of Anchoring Short Lengths of Rail by Means of a Wood Strain Insulator.

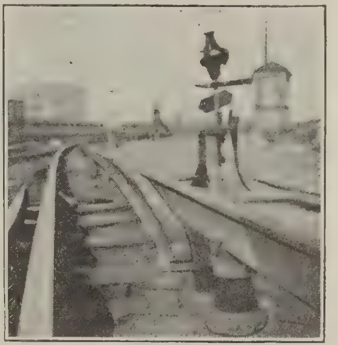


Fig. 5. Side Incline Approach.

The Quality of Rail.

The conductivity of the rail will vary inversely with the percentage of carbon or manganese allowed to remain in the finished rail. Increasing the conductivity will, however, make the rail considerably softer, requiring careful handling. The rate of wear of low carbon and ordinary steel is about the same. In Mr. Jones' opinion there is nothing to be gained by insisting on high conductivity when using rail weighing less than 80 lbs. Above 80 lbs., the question requires careful consideration, for the gain in conductivity costs almost as much as paralleling the rail with a copper feeder system. The problem of insulating the contact rail of a 600-volt system is more a mechanical than an electrical one. Porcelain, reconstructed granite, or insulators having castings bolted together have not been satisfactory when there is vibration. An insulator should be so designed that it has a large leakage surface so as to prevent current leakage during wet weather. A type of impregnated wood insulator has proven very satisfactory on this road for rails weighing from 40 to 80 lbs. The base casting is the same size for all weights of rail; the length and top of casting are varied for the different weights of rail. The spacing should not be greater than 10 ft.; otherwise the rail will wear in spots. An

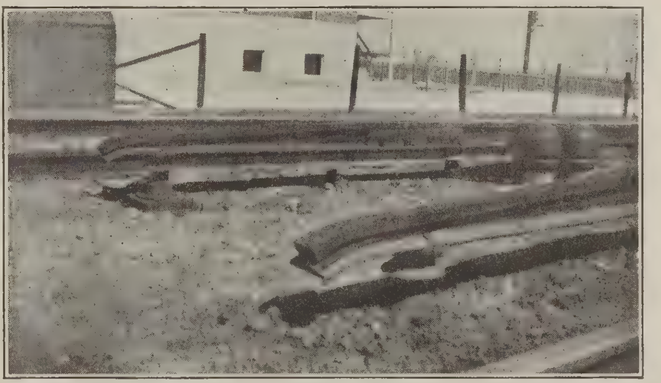


Fig. 6. Incline Made by Cutting Web Out of Steel Rail.

insulator will ordinarily last from 10 to 12 years, although in one system many impregnated wood insulators have lasted from 15 to 20 years.

Copper bonds with a current carrying capacity equal to that of a solid rail are used for joining the rails. To control variation in the length of rail, due to temperature changes, it is cut up into lengths from 1,000 to 1,200 ft. These sections are anchored in the center so all expansion takes place at the ends. One method of anchoring these sections is to connect several strain insulators in multiple to an iron plate which is extended over and bolted to several ties. The other end of these insulators is attached to the base of the rail. The expansion gaps between these stretches of rails is best taken care of by ending each run of rails with a suitable incline and leaving a 3 or 4 ft. space between each stretch of rail.

A good method to follow on a third rail is to provide the incline at the end of a full length rail. Mr. Jones also described several methods of guiding the contact shoe onto an incline.

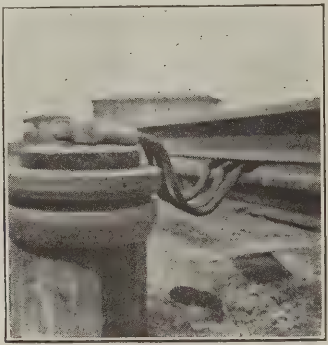


Fig. 7. Crossing Connection Cable Terminal for Protection Against Breakdown, for Use With Clay or Fiber Duct or Iron Pipe.

Mr. Jones gave data on the laying of third rail of different weights. The cost per mile of single track, using 80-lb. A. S. C. E. standard rail in 60-ft. length, is $3,309.52 and $352.80 for labor, making the total cost for labor and material with 10% for supervision, $4,028.55. The cost for laying a mile of single track, 50-lb. A. S. C. E. rail in 30-ft. lengths, is $2,507.52 for material, $478.20 for labor, plus $298.57 as the 10% charge for supervision, or a total cost of $3,284.29. The estimated cost of maintenance per mile of contact rail is $80.00. This does not, however, include a complete renewal of rails, plates and bonds such as will occur when the rail is completely worn out.

The Contact System of the Southern Pacific, Portland Division

Paul Lebenbaum, electrical engineer of the Portland, Eugene & Eastern Railway, describes the overhead contact system of the electrified lines of the Southern Pacific Co. He enumerates the designs, materials of construction and tabulates the material and labor costs. The electrified lines of this company extend from Portland to Whiteson, a distance, via Forest Grove, of 54 miles and via Newberg, 45.2 miles, as shown on the accompanying map. The total single track mileage of the main line is 104 miles, with approximately 16 miles of electrified second track and sidings. The operating potential is 1550 volts, with the exception of 3 miles of 600-volt trolley in Portland. Construction began in July, 1912, and the lines were put in electrical operation in January, 1914.

The side bracket type of catenary construction is used for the most part, the poles being placed on the outside of curves, cross span construction being used where the poles change from one side of the track to the other.

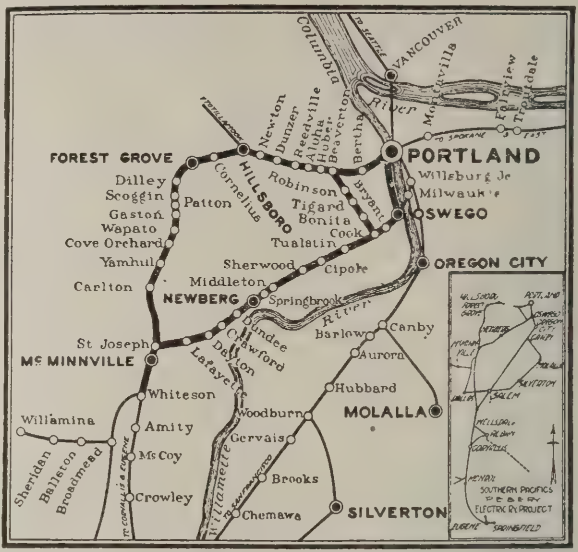
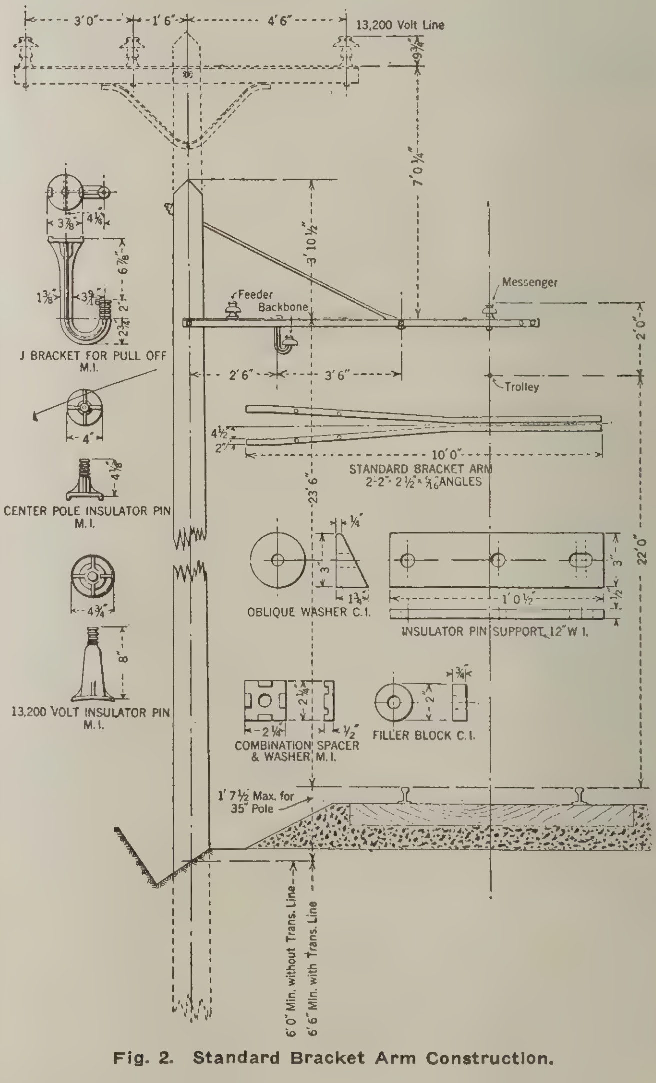


Fig. 1. Map Showing the Extent of Present Electrification and the Ultimate Plans of the Southern Pacific Co., Portland Division.


3'0"
1'6"
4'6"
13,200 Volt Line
9¾"
7'0½"
3'10½"
Feeder
Backbone
Messenger
2'0"
2'6"
3'6"
Trolley
J BRACKET FOR PULL OFF M.I.
3⅞"
4⅜"
6⅞"
1⅜"
2"
2¾"
4"
4½"
10'0"
STANDARD BRACKET ARM 2-2"×2½"×3/16" ANGLES
CENTER POLE INSULATOR PIN M.I.
4⅞"
23'6"
22'0"
¼"
3"
1¾"
OBLIQUE WASHER C.I.
1'0½"
1½"
INSULATOR PIN SUPPORT 12" W I.
4¾"
8"
13,200 VOLT INSULATOR PIN M.I.
2¼"
½"
COMBINATION SPACER & WASHER M.I.
¾"
FILLER BLOCK C.I.
1'7½ Max. for 35' Pole
6'0" Min. without Trans. Line
6'6" Min. with Trans. Line
Fig. 2. Standard Bracket Arm Construction.

On tangets the standard pole spacing is 150 ft., but the average spacing is approximately 98 ft., since that portion of the road lying between Sherwood and Springbrook is exceedingly crooked, and 25% of the main line mileage is in curved track. The standard pole length for catenary construction is 35 ft., for transmission and catenary, 40 ft. The cost at the hole of various lengths of pole having a 9-in. top is $6.90 for 35-ft. pole, $7.50 for the 40-ft., $25.00 for the 45-ft., $8.85 for the 50-ft., and $9.60 for the 55-ft. pole. All poles were given two thorough brush treatments with carbolineum avernarux from a point 18 in. above the ground to within 3 ft. of the bottom. The preservative was applied by means of burlap fastened to the ends of long mop handles and was kept hot by steam coils placed on the bottom of the shallow tank, over which the poles were rolled. Approximately one gallon of preservative was used per pole, at a cost of about 50c apiece.

All pole and line material is galvanized or sherardized, all bolts and nuts being given the latter treatment. Hangers are installed at 15-ft. intervals; the line is sectionalized at all junction points, at substations, and where the voltage changes from 1,500 to 600. To eliminate hard stops a section brake has been developed, consisting of 2 parallel wires suitably insulated from each other.

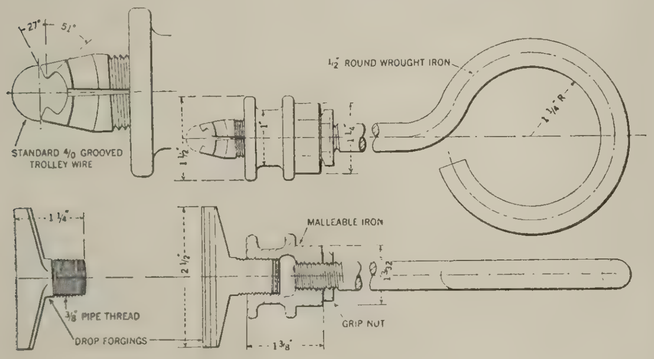


Fig. 3. Catenary Hanger, Loop Type.

The cost per mile of tangent construction is $1,500.00 for material; $600 for labor, totaling $2,100.00. Curves and sidings increase these costs about 20%. The loop type of catenary hanger is used, as shown in Fig. 3. Flexibility is extremely desirable in a contact system from which current is taken by roller pantograph on account of the inertia of the collector. This is very evident on curves. The curve pull-off construction is shown in Fig. 4.

Data on maintenance cost from October 1, 1914, to March 31, 1915, make the cost per mile per year for (104 miles) for the material, $7.73, labor, $70.38, or a total of $78.11. The maintenance crew consisted of one foreman, three linemen and four ground men. This crew handles in addition to the contact system, all repairs to the 13,200 volt transmission line and 2½ miles of 60,000-volt transmission line. The crew uses gasoline section motor cars equipped with towers for line inspection repair; the average train mileage is 1,460, and the schedule speed 20 miles per hour. The average running current per motor is 200 amperes. The average motor car miles per day was 3041, the average trail car miles per day, 560, and the weight of motor car, 53 tons.

The current collectors are fitted with roller bearings in place of the graphite bushings formerly used. This makes the cost of maintenance of the roller collecters per thousand motor car miles a trifle over 40c, figured for the period of January 1, 1915, to April 14, 1915. The collectors are made of 5-in. steel tubing with a 7/32-in. wall and operated at a pressure against the wire of 30 to 38 lbs. Defective tubing has kept the mileage per collecter down to 9,696 miles. The wear on the trolley wire to date has been inappreciable.

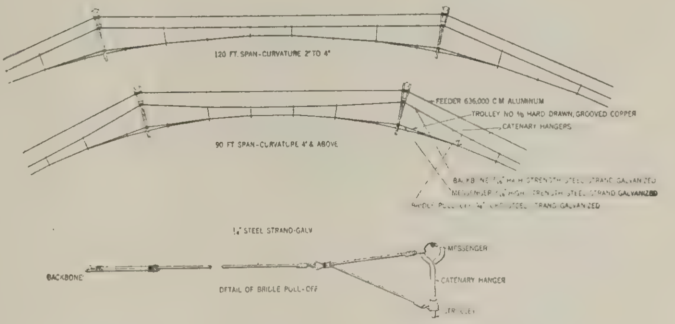

120 FT. SPAN-CURVATURE 2° TO 4°
90 FT. SPAN-CURVATURE 4° & ABOVE
FEEDER 636,000 C.M. ALUMINUM
TROLLEY NO 4/0 HARD DRAWN, GROOVED COPPER
CATENARY HANGERS
BACKBONE 7/16" HIGH STRENGTH STEEL STRAND GALVANIZED
MESSENGER 7/16" HIGH STRENGTH STEEL STRAND GALVANIZED
1/4" STEEL STRAND-GALV
BACKBONE
DETAIL OF BRIDLE PULL-OFF
MESSENGER
CATENARY HANGER
TROLLEY

Fig. 4. Pull-Off Construction for Curves, Showing Details.

Electrical Improvements on Various Roads

The Southern Pacific Company have recently completed a large new two-story brick building at the West Oakland Yard to be devoted exclusively to train lighting work at this point. All modern conveniences for the handling, maintenance and repairs of batteries, a swell as axle light and headend equipment are provided for. The entire yard is being wired underground conduit and charging plugs will be placed every 90 ft. A rectifier plant is being discontinued and motor generator sets of ample capacity to take care of all battery charging are being installed. They are also building a new train lighting shop in San Francisco and installing a new yard charging equipment for handling storage battery work.

About six months ago they built a new train lighting shop at the Los Angeles yards and expect very soon to have all the train lighting shops at the various points well equipped and in good working order in spite of the greatly increased amount of work, due to the exposition traffic.

The Illinois Central have recently equipped some of their private cars with two sets of batteries connected in parallel. These are connected to a double pole throw, 100 ampere switch and two registor type ampere hour meters are installed, one in each battery circuit. The system is arranged so that the generator charges one of the batteries only, the other being held in reserve. The ampere hour meters serve both as an indication as to the amount of charge remaining in the battery, and also serve to discontinue charging when the meter shows full charge.

It is found that this arrangement has proven more satisfactory than when two batteries were connected permanently in multiple and for private cars, where car often stands for several days, these batteries can be charged individually without interference with the lighting arrangement, one of the batteries being used, while the other is being charged. It is stated that wherever two batteries are installed on a single car in the future, the system will be connected to operate in this manner. Whenever it becomes necessary to charge both batteries at once, the double throw switch is open and two charging lines are used to each battery.

Semi-Annual Convention

Association of Railway Electrical Engineers, Atlantic City, N. J., June 12, 1915

The Semi-Annual Convention of the Association of Railway Electrical Engineers, held at the Hotel Dennis, Atlantic City, N. J., was called to order by President H. C. Meloy on June 14, 1915.

As new business Mr. Sloan pointed out that in the proceedings of the American Institute of Electric Engineers, there is a notice relative to the classification of technical literature to the effect that delegates from about twenty national and scientific societies met in New York recently to perfect a permanent organization, the purpose being to prepare a classification of the literature of the applied science which might be generally applied and adapted by these other organizations. This body will be known under the name of the Joint Committee on Technical Literature. It was moved that an attempt be made to have Mr. Sloan appointed as a member of this committee.

Committee Reports.

The first report of the standing committees was that of the Committee on Standardization of crane, transfer and turntable motors, etc. Their expressed intention is to obtain information relative to the crane transfer and turntables which are in service on the various railroads in the United States. From this information the committee will arrive at standard speeds for the different capacity cranes, etc., which will assist them in determining the requirement of the motors for use therewith.

Mr. E. Wanamaker gave a most interesting outline of the work which he has laid out for the committee on the Generation of Compressed Air. Mr. Wanamaker was appointed chairman of the committee at the last minute, but in spite of that a very detailed plan of investigation has been laid out.

The report is to be taken up in two sections; first, a description of the various forms of power for driving air compressors, the uses and abuses of compressed air from shafts, terminals, yards, etc. He pointed out two prominent features which govern the selection of power for driving air compressors: first, the cost of steam, electric or oil engine power delivered to the piston rods of the compressor pistons, and second, the cost of the distributing mains and laterals. To arrive at this last cost, three different and distinct installations will be worked out; one, where a motor driven compressor will be advantageous, and second, where an oil engine compressor should be used, and a third, where a steam driven compressor would give best results.

Mr. J. L. Minick, of the Pennsylvania, suggested that there be included in this report a description of some satisfactory method of determining the amount of leakage in the air lines.

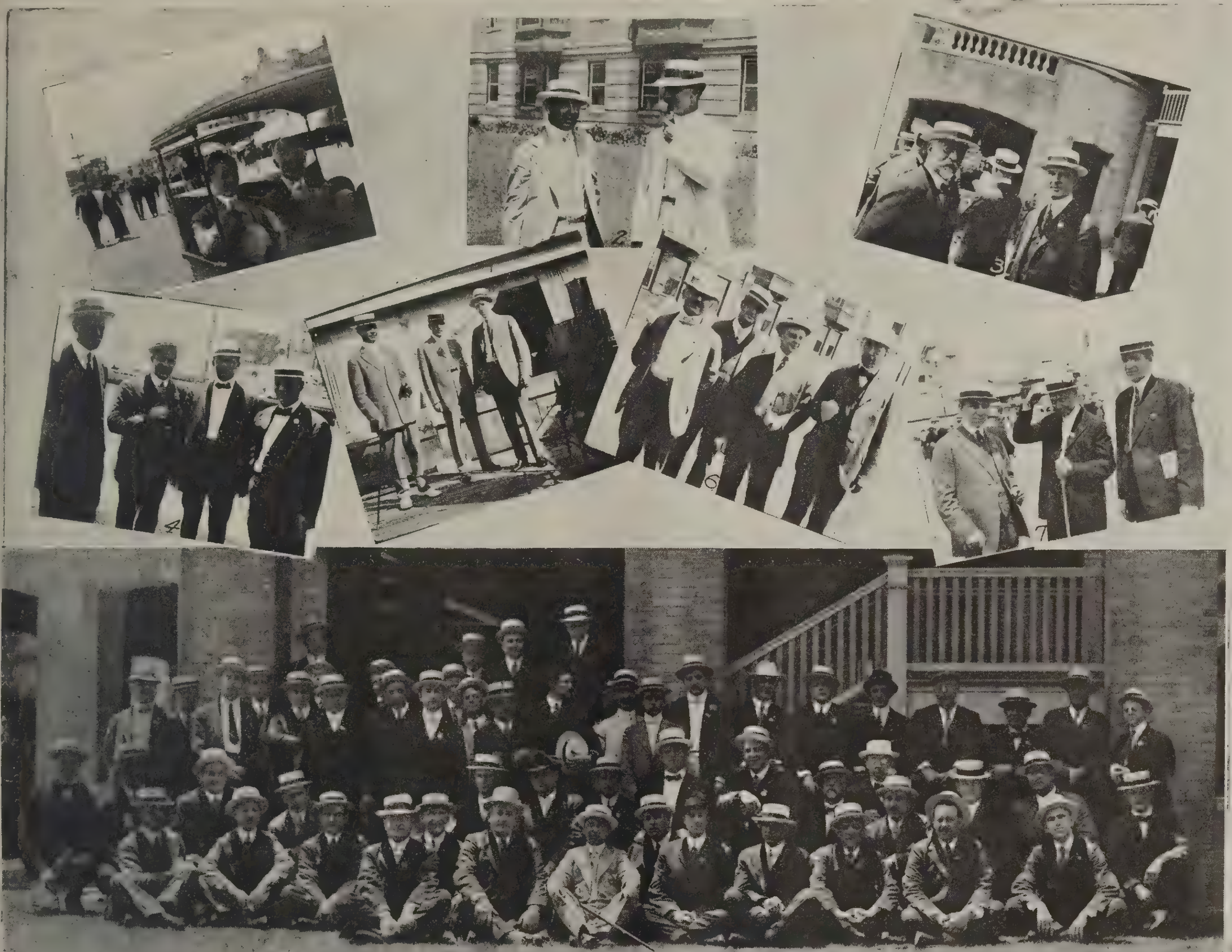
Mr. Thos. Foltz, of the Washington Terminal Company, pointed out that where air is supplied to several companies from a central compressor plant, it is very difficult to meter the delivered air accurately. He stated that in most cases meters would not check a displacement test within 20 per cent. Mr. Wanamaker pointed out, however, that the Nordberg people have designed an air flow meter which gives most accurate results. The operation of this meter is based upon the Venturi tube principle and that the effect of the expansion coefficient on the meter due to a variation in the temperature is taken care of thermostatically. He also stated that the inefficient operation of air compressors was very apt to be caused by the water jacks filling up with mud, which prevents the proper cooling of the air.

Mr. Minick, chairman of the Committee for Rating Train Lighting Lamps, said that requests had been made by the lamp manufacturers that train lighting lamps should have a uniform rating, inasmuch as a great many changes and improvements in the sizes and efficiency have been brought about. At the present time the actual wattage of train lighting lamps varies considerably from the rated watts and the manufacturers think it desirable that this discrepancy should be removed. The committee suggested two possible courses of action; first, to bring the actual wattage and rated voltage more closely in accord; second, to recommend some policy to be observed in future improvements in train lighting lamps; third, to recommend some policy for the future rating of train lighting lamps. The committee has recommended to the manufacturers that the actual watts be held constant and improvements in efficiency be allowed to go into increased candle power until an efficiency of approximately one watt per mean horizontal candle power is reached, then after this point is reached the improvement in efficiency should be allowed to decrease the wattage of the lamp. The committee believed that the introduction of the gas filled lamps will shortly make it necessary to abandon "mean horizontal" for "means Spherical" candle power as the basis for lighting lamps.

Mr. W. H. Cairns suggests that as the manufacturers have discontinued designating lamps by the candle power that they should be rated on the watt basis exclusively, but Mr. D. J. Cartwright felt that lamps should be rated by their lumen output, since the amount of illumination that a lamp produces is the factor which engineers are most interested in, the lumen being the measure of the light flux of a lamp. Mr. A. L. Broe, of the General Electric Company, believed that as lamps have always been rated in watts, it would be desirable from a standpoint of uniformity to continue this practice at least for the present. Mr. J. R. Sloan, as chairman of the Committee on Loose Leaf Binders, read the progress report of that committee. This committee thinks that a desirable loose leaf binder should require a minimum space for binding, should be flat opening, should hold any number of sheets securely, and should permit the removal of any sheet without disturbing the others.

The Committee on Wire Crossing Specifications, of which Mr. Sloan is chairman, has attempted to obtain representatives on the National Joint Committee on Overhead and Underground Line Construction, but this request was not granted on the ground that railroads were already adequately represented.

The Committee on Standards was given by its chairman, Mr. D. J. Cartwright. This committee met jointly



At the Semi-Annual Convention of the A. R. E. E. at Atlantic City, June 14th.—1. H. G. Thompson and Friend Taking Life Easy on the Board Walk; 2. J. A. Andreucetti and J. R. Sloan in Their Hot Weather Togs; 3. D. J. Cartwright, E. W. Jansen in Front of Hotel Dennis; 4. Group on Hotel Dennis Lawn; 5. J. E. Kilker, R. L. Kilker and C. E. Miller Beside Their High Pressure Steam Boiler; 6. Messrs. Newbold, Meyers, Ballantine and Gassaway, of the Willard Co.; 7. MacGinness and Luckey of the Edison Storage Battery Co. on the Board Walk; 8. W. L. Bliss and T. L. Mount; 9. W. E. Fawcett of the Main Belting Co.; 10. Warren Young of the Kerite Co., and E. W. Jansen; 11. George Berger and P. H. Simpson of the Gould Co.; 12. H. D. Rohman of the Stone Co.; Geo. R. Berger and Secretary Andreucetti; 13. L. S. Biliau of the Baltimore & Ohio; J. L. Woodbridge of the Electric Storage Battery Co.; 14. J. E. Gardner, of Burlington, and E. Wannamaker, of C. R. I. & P. Ry., and H. C. Meloy, L. S. & M. S. Ry. and Mr. Wilson, of Central Elec. Co. in background; 15. Convention Group Outside of Hotel Dennis.

with the M. C. B. Train Lighting Committee. This joint committee recommends that fuses be placed as close as possible to the generator and that the dimension of battery boxes be changed by reducing the distance from front to back 3 in., that all new or remodeled generators have a pulley 8 in. or 11 in. in diameter and that all new or remodeled dynamos with armature shafts 1⅝ in. or over be provided with a taper pulley fit of 1½ in. in 12, for shafts having a diameter of less than 1⅝ in., the recommendation is made that the pulley fit be ¾ of an inch in 12. Ball bearing and roller bearing generators should use the 412 size bearing.

The Committee on Industrial Trucks are standardizing speeds, capacities and voltages of industrial trucks. The co-operation of the tire and battery manufacturers has been obtained and these are now prepared to furnish the size recommended by the A. R. E. E. Similar word is expected from the truck manufacturers relative to the overall length, weight and height and wheelbase of the trucks, the tread and height of platform and the training radius.

The Committee on Car Wiring Specification, of which Mr. L. S. Billau is chairman, has prepared model specification covering car wiring and other electrical features of passenger cars so that they may be adapted either in their entirety or in part by railroads, car builders and others. In their tentative form they are given below.

Electric Lighting Specifications for Passenger Cars

General.

These specifications are intended to cover the complete installation of an electrical wiring system for the lighting of passenger cars that will meet the requirements of the Board of Fire Underwriters Rules.

It shall be understood and agreed that these specifications shall be fulfilled in their true spirit and meaning, to the satisfaction of the Electrical Department of the Railroad Company and shall provide for a first class and complete system of wiring in every respect. It shall be further understood and agreed that any apparatus or appliance essential to the safe, proper or convenient operation of the system shall be supplied and installed at cost, even though such appliance be not called for in these specifications.

The wiring shall be arranged for use in connection with axle-driven volt generator or head end volt generator operated in conjunction with a storage battery mounted under car body. The wiring system shall be complete, including conduit, conduit fittings, outlet boxes, switches, cutouts, fuses, sockets, fixtures, wires, cables, etc. The wiring shall be in accordance to prints approved by the Railroad Company.

The car builder shall furnish blue prints showing conduit plan, wiring diagrams and any other prints necessary for the application of electrical equipment. The builder shall also furnish print of the details and application as he interprets the lighting arrangement and submit them to the Railway Company for their approval before starting work. A floor plan showing the location of lights shall accompany specification of each class of car. An under body print showing location of equipment boxes and all other apparatus placed under car body shall be furnished. The car builder must in all cases advise themselves that the specifications in their possession are of the latest revision. The standard rules for car wiring of the A. R. E. E. shall govern the installation of conduit and wires on all cars.

Standard Rules for Car Wiring Conduit and Fittings

Section "A."

No. 1.—All wiring must be done in approved galvanized or sheradized steel conduit of sufficient size to allow for the pulling in freely of all wires after conduit is in place.

No. 2—Conduit must be so arranged that wires can be renewed without necessitating the removal of the interior finish of the car.

No. 3—Conduit and fittings to be firmly and substantially fastened to the framework of the car.

No. 4—Fittings must be so installed that the covers of all fittings will be accessible.

No. 5—Ends of conduit must be cut square and reamed smooth and must be butted together in couplings.

No. 6—No conduit smaller than ⅜″ shall be used.

No. 7—Where pipe threads are exposed they must be leaded and painted.

No. 8—All conduit for circuit wiring must be run inside the car.

No. 9—Conduit for generator leads shall run direct from the generator connector to the regulator locker and must not be less than 1¼″ in size.

No. 10—Conduit for battery leads and charging plugs shall run to a junction box located near the battery box.

No. 11—Conduit for battery wires shall run from a junction box located near the battery box direct to to regulator locker.

No. 12—A junction box must be placed in the conduit where a reverse or double bend occurs or the run too long to allow the wire to be readily fished through the conduit.

No. 13—Junction boxes and outlet fittings exposed to the weather shall be of cast iron, to be made of one piece and have threaded hubs that shall engage at least five threads and have integral bushings.

No. 14—The conduit must be so constructed so as to form one perfect electrical conductor and this shall be connected by the ground clamp to the iron framework of the car.

No. 15—Connection from conduit to ground must be exposed to view and readily accessible and must be made of a wire of at least No. 6 B. & S. gauge.

No. 16—Light fixtures and fans must be either thoroughly insulated from or else solidly connected to the framework of the car and conduit system.

Section "B"—Generator Lead Connector.

No. 1—A generator lead connector having no exposed live parts and so constructed that no tools will be necessary to make and break connections, and that the polarity cannot be reversed when the plug is inserted; to be used to connect the generator leads to the wiring on the car body.

Section "C"—Charging Receptacle.

No. 1—A charging receptacle shall be placed on each side of the car six inches back from the side under the bottom of the car.

No. 2—Receptacle must be designed so that the strain of the plug is taken on the frame of the receptacle and not on the contact parts of either plug or receptacle.

No. 3—Contact parts must be self-aligning with each other and with the strain on the charging line.

No. 4—These receptacles shall be housed in swivel cast fittings with self-closing doors.

Section "D"—Wires.

No. 1—All wires and cables must be insulated with Grade "A" insulation according to specifications of the A. R. E. E. and must be double braided.

No. 2—No wires smaller than No. 14 B. & S. gauge shall be used.

No. 3—Main circuit wires shall be at least No. 12 B. & S. gauge.

No. 4—All wires of No. 8 or larger must be stranded.

No. 5—Generator leads and train wires must be extra flexible as prescribed.

No. 6—Slack wires must be left at all outlets and junctions.

No. 7—No joints or splices will be permitted in conduit between junctions or fittings.

No. 8—All joints in wires and cables must be so spliced or joined as to be both mechanically and electrically secure without solder.

No. 9—All joints must be soldered.

No. 10—The soldering flux must be free from acid.

No. 11—The insulation on wires must be removed without marking or cutting the wire.

No. 12—Care must be taken that no sharp point of wire or solder is left to pierce the insulation and cause a ground.

No. 13—The joint must be covered with approved splicing tape of sufficient thickness to make the joint equal in insulation to the rest of the wire; this shall then be covered with approved friction tape.

No. 14—The generator leads from dynamo to the terminal connector on the car body shall consist of No. 4 B. & S. gauge extra flexible stranded (133 strands) conductor covered with Grade "A" insulation and one linen braid saturated with weather-proof compound.

No. 15—All generator leads to be enclosed in a canvas hose or equivalent protection.

No. 16—The train connector cable to be of No. 2 B. & S. gauge extra flexible (133 strands) insulated with Grade "A" insulation and covered with a weather-proof braid or No. 2/0 B. & S. gauge flexible stranded (836 strands) covered with Grade "A" insulation and weather-proof braid.

No. 17—Battery conductor cable must be No. 4 B. & S. gauge stranded (133 strands) insulated with Grade "A" insulation but with no other covering.

No. 18—Battery leads to be supported from top of battery box by a series of insulated hooks.

Section "E"—Fuses and Cut-outs.

No. 1—Each circuit of the car wiring must be provided with an automatic fuse cut-out in each wire placed on the switchboard and the fuses in the same so proportioned that they will blow and disconnect the circuit before the wires become overheated.

No. 2—The fuses protecting the generator shall be located on the regulator panel.

No. 3—The fuses protecting the batteries must be located in a substantial cast iron weather-proof fuse-box with hinged cover and substantial wing-hut catch just outside of the battery box.

No. 4—No taps for regulator wiring shall be connected on the lamp circuit outside of the fuse cut-outs.

No. 5—The table of "Allowable carrying capacities of wires" issued by the National Board of Fire Underwriters shall guide installation of all cut-outs.

Section "F"—Switchboard.

No. 1—The switchboard must be made of one piece of oiled Monson slate.

No. 2—It must be so constructed that fuse cut-outs and circuit switches can be removed or replaced without taking down the switchboard.

No. 3—The main circuit switch must be placed on the switchboard and must be proportioned to the connected lead, but must be built for a minimum of 100 amperes capacity. This rule applies to train line switch also.

No. 4—They must be equipped with stamped open link fuses fastened with wing-nuts.

No. 5—The main circuit switch must control both sides of the circuit, and must separate the car wiring and the lamp voltage regulator from the battery and generating system when opened.

No. 6—All connections on switchboard must be made with the positive to the right facing switchboard. When vertical mounting makes this impossible the top connection shall be positive.

Section "G"—Regulator Locker.

No. 1—The regulator locker must be metal lined or constructed of steel not less than 12″ in depth and 20″ in width.

No. 2—Where the generator and lamp regulator are mounted in the locker, the height to the top of the door opening must not be less than 40″ and where the switchboard is placed in the same locker the height shall be governed by the number of circuits on the board, but must not be less than 56″.

No. 3—The regulator shall be mounted on Z irons which must be securely fastened to the back of the locker by bolts where the construction permits and where screws are used they must be spaced not more than 4″ apart.

No. 4—The switchboard and regulator panels must be secured with ⅜″ hex-head bolts which must be slotted for screwdriver. The Z iron shall be tapped to take the standard ⅜″ bolt.

No. 5—The locker shall be ventilated with not less than 4″ pipe carried through the roof of the car and equipped with a roof jack. A 2″ nipple shall extend through the car floor with a bushing at both ends. A piece of copper screen shall be fitted between the ends of the pipe and the bushings.

No. 6—Where the locker is built below the door level the bottom of the locker must be closed so that material or rubbish cannot accumulate in it.

No. 7—Where door extends to the floor a false bottom shall be placed in bottom of the locker at the angle of 45 degrees so that rubbish cannot be swept into the locker. Under no circumstances will the mounting of the regulator below the level of the door opening be permitted.

Section "H"—Fixtures.

No. 1—The fixtures must be designed so as to be easily wired, all corners to be rounded off to prevent abrasion or cutting of the wires when they are pulled in.

No. 2—A high grade heat resisting insulation must be used on all fixtures wire and in the composition of the sockets.

No. 3—In the construction of sockets nothing less than a standard ⅜″ socket base with standard pipe threads and center spring contact must be used.

No. 4—The use of fine thread small machine screws in the make up of fixtures will not be permitted.

No. 5—All fixtures of any certain design must have a standard base with holes bored to a template so that when the fixture is removed another of the same design can be put in its place without necessitating the boring of new holes.

The members of the association are requested to look over the specifications and send in written corrections and suggestions so that they may be incorporated in the final report for October.

The progress reports of other standing committees indicated that they were working along similar lines to last year. The Committee on Shop Practice intends to consider the following subjects, first, Electricity vs. compressed air for portable tools; second, Electric furnaces for hardening tools; third, Crane magnet and magnetic chucks.

Mr. Wray's Committee on Data and Information will collect data showing the trend of use of various types of lighting and power equipments. The recommendation was made that a special committee be appointed to co-operate with this committee to obtain data on transformers in railroad service. Mr. J. H. Bryan of the Westinghouse Mfg. Company thought that as manufacturers of transformers have gotten out a good line of standard ratings, both as to capacity and ratios, that there would be no need for such a committee being appointed. This recommendation was referred to the executive committee for consideration.

At Mr. Cartwright's suggestion a committee will be appointed to draw up specifications for car lighting generators. Specifications will be so drawn up that when a two or three k.w. machine is ordered of a manufacturer it will be understood that the rating is made under certain definite conditions.

This concluded the business of the convention and adjournment was taken until the fall meeting, which will be held in Chicago, October 18th to 24th, 1915.

Exhibits

Consolidated Ry. Light & Equipment Co., of New York, exhibited an operating axle car lighting system with a type L-3 generator regulator and a type "F" lamp regulator. The generator was of the type B-5, having 4 k.w. capacity and was mounted with S.K.F. ball bearings. The operation of the ampere hour meter with this equipment has already received attention in the RAILWAY ELECTRICAL ENGINEER. In this equipment the voltage coil acts as a check on the operation of the meter. The company was represented at the Convention by Messrs. J. L. Watson, T. L. Mount, and P. Kennedy.

Edison Storage Battery Co., of Orange, N. J., exhibited in their booth, nickel iron storage batteries for use in freight and baggage trucks, car lighting, signal and telegraph service. A large panel in the rear of the booth was of much interest. In the center of this panel was an illuminated photograph of the plant, this was bordered by illuminated photographs showing the different processes used in the manufacture of these batteries. Grouped around the outside of the panel were parts of dissembled battery, and batteries shown complete with the case cut away, which showed the constructional details of the batteries very well.

Some of the newer batteries which were exhibited were small miner's batteries about 2 in. by 8 in. in size. These have recently been approved by the Bureau of Mines. A positive and a negative plate of a large submarine battery of the type now being manufactured for the government were exhibited; each plate has a capacity of about 400 amperes. The company was represented by Messrs. H. G. Thompson, W. F. Bauer, F. V. McGinness, Otto Hildebrant, C. A. Luckey.

Electric Controller & Mfg. Co. This company had on exhibit several of their push button dynamic braking controllers for d.c. motors. They also exhibited their Youngstown safety limit stop for direct current motors. This prevents cranes and other kinds of lifting apparatus from overtraveling and in this way prevents many costly wrecks. Messrs. E. C. Ryan, W. C. Jackson and R. G. Widows were the company representatives at the convention.

Electric Storage Battery Co., of Philadelphia, had on exhibit a complete operating equipment. One of their new 50 ampere car lighting generators was mounted on a dummy truck and was driven by a motor. The new E. S. B. control panel combines the auxiliary switch and main switch into one unit. They featured a complete set of pamphlets, which described all the various products which are made by them.

Their exhibit of storage batteries was very complete. Various types of automobile starting and lighting batteries were shown. Batteries for use in trucking and house lighting, besides their standard car lighting batteries were exhibited. They also exhibited their equipment for an isolated electric plant, consisting of a gas engine or other source of power, coupled to a generator and regulating outfit and storage batteries. This is called the Hyray Exide outfit. The company representatives at the convention were Messrs. E. L. Reynolds, J. L. Woodbridge, F. G. Beetem, H. E. Hunt.

The Edison Storage Battery Co. Booth, Showing the Self Illuminated Panel Board in the Background.

General Electric Company, of Schenectady, had a very comprehensive exhibit of their products which are of interest to railroad men. A large electric hardening and annealing furnace with a heating chamber 8 in. high and floor dimensions of 16 x 18 in., consuming 40 k. w. was shown. This is air tight, so little corrosion results from oxidization of the metal being heated.

Their standard 300 ampere portable arc welding equipment consisting of motor generator set and its accessories was one of their operating exhibits. Indicating, recording and integrating flow meters were shown for use with steam, water, air or oil. The constant "Safety First" starter, a contactor control reversing apparatus, adjustable speed control equipment, wheel lathe control and a line of push button stations were exhibited. They also exhibited their R-178 controller and their new type RC direct current motor.

The company was represented at the convention by Messrs. B. F. Bilsland, W. J. Clark, F. B. Hartman, D. B. Rushmore, C. D. Knight, C. Fair, J. Eaton, J. W.

Ham, W. L. Merrill, P. A. Dyer, F. M. Kimball, W. O. Kellogg, C. A. Boers, Mr. Raymond and Mr. Williams.

Gould Coupler Co. and Gould Storage Battery Co. occupied the same booth which they have had for several years. The Gould "Simplex System" for the electric car lighting, which was on exhibit, consisted of a standard Gould regulation panel, Gould batteries, a motor generator set operating at a speed which would correspond to a range from zero to 85 miles an hour in train speed.

Booth of the Electric Storage Battery Co. at the Atlantic City Convention.

The Gould high bridge no-wash car lighting batteries were on exhibition for the first time. The Coupler Co. also exhibited their malleable iron journals, friction draft gears, passenger and freight car couplers and other mechanical devices. Messrs. George G. Milne, F. P. Huntley, W. F. Richards, Dr. C. W. Gould, Clarence F. Rood, G. R. Gerger, M. R. Shedd, W. F. Bouche and P. H. Simpson represented the company.

H. W. Johns-Manville Co., of New York City, exhibited their molded insulators, fuses, line materials, their asbestos materials, such as pipe coverings and car insulators. Of especial interest to car lighting men was their acid proof flooring for use in battery houses. Their new mechanical slack take-up caused considerable comment.

Those who represented the company were Messrs. J. E. Meek, F. J. Horn, H. G. Newman, George Christenson, and J. C. Jacobs.

Kerite Insulated Wire & Cable Co., of New York City, were at home in their reception booth, and were represented by Messrs. Major Azel Ames, P. W. Miller and J. A. Renton.

Okonite Company of New York conducted a reception booth at the convention. The company representatives were Messrs. W. T. Kyle and Francis J. White.

Pyle National Headlight Co., of Chicago, exhibited their type "E" arc headlight equipment and type "K" incandescent equipment. A flash boiler, furnishing steam at pressures varying from 50 to 800 pounds per square inch, ran the turbo generator. It was stated that this resulted in a speed variation of only 2%.

A full size operating model of their new Young valve and their Young reversing gear attracted much attention. Van Dorn one piece and three piece steel car ends were also shown.

The company representatives were J. Will Johnson, R. C. Vilas, William Miller, J. E. Kilker, O. W. Young, C. E. Miller and R. L. Kilker.

Railway Utilities Company, of Chicago, exhibited their different types of exhaust ventilators. These have a maximum exhausting capacity and prevent reversed drafts from carrying snow, rain and dust back into the car.

The company was represented by Messrs. G. E. Pratt, W. J. Pine, James Denton, and G. Magersteadt.

Safety Car Heating & Light Co., of New York, had their usual complete exhibit of car lighting fixtures for passenger, baggage and postal cars. The unit which combines a ceiling fan and a lighting fixture was also shown.

The most interesting feature of this exhibit was an operating model of the new underframe car lighting generator. This was a 3 k. w. generator mounted as it would be under the frame of the car and driven from a dummy axle at speeds corresponding to train velocities of from zero to 85 miles an hour. The effect of curves on the tension of the belt was well demonstrated by swinging the generator from zero to 27½ deg. on either side of the line passing through the center of the axle pulley face. The equipment was maintained under any desired load to show the small effect of curves on the machine operation. This equipment was described in the April issue of the RAILWAY ELECTRICAL ENGINEER.

The Exhibit Booth of General Electric Co.

Messrs. R. M. Dixson, A. C. Moore, J. S. Henry, R. C. Shaal, G. E. Hulse, W. I. Thomson, W. L. Garland, G. H. Chadwell, C. W. Walton and W. H. Reader were the company representatives at the convention.

U. S. Light & Heating Co., of New York, exhibited their type "C" regulating panel with auxiliary switchboard and meters which indicated voltages at the various points throughout the system. A generator, with part of the field casing sawed away, showed the special ball bearing mounting. Their regular pasted car lighting battery plates were shown and an operating panel with a Sangamo ampere hour meter for battery control was also exhibited.

The last development of the company which was shown was their stationary belt guard for use with flangeless pulleys. This resembles a pully with a stationary flange. This retains the advantages of a flanged pulley but with it the belt has no tendency to climb as it does with a revolving flange. Their battery exhibit consisted of a full line of stationary, signal, car lighting, truck and sparking batteries. A panel board with parts mounted on it showed the assembly and method of manufacture of U. S. L. battery. The company was represented by Messrs. B. F. Bisland, W. J. Clark, F. B. Hartman, D. Bradford, H. A. Matthews, and J. A. White.

A Commodious Reception Booth of the Westinghouse Companies.

Westinghouse Electric & Mfg. Co. As has been the custom of this company for a number of years, no apparatus was exhibited. A well lighted comfortable reception room was the company's exhibit. The mural decorations were photographs of the latest Westinghouse developments.

The representatives of the company who were present at the convention were W. H. Patterson, H. C. Mode, L. W. Popp, R. F. Moon, J. L. Hays, J. C. McQuiston, H. W. Beaumot, Q. W. Hershey, M. B. Lambert and W. R. Steinmetz.

Willard Storage Battery Co., of Cleveland, exhibited their Willard "no-wash" batteries. A partially dissembled battery with the various parts showed the construction and assembly of the battery. This was described in the October 1914 issue of the RAILWAY ELECTRICAL ENGINEER.

Representatives of the company were Messrs. W. E. Ballantine, F. S. Gassoway, R. M. Newbold, L. Sears, and E. L. Meyers.

Pasted Plates in Car Lighting Service

When one considers the thousands of motor trucks which are equipped with lead batteries with pasted type plates and which are operating successfully in this service, giving reasonably long life, the natural question is, "Why isn't the pasted type plate used by railroads for electric car lighting service?"

Men who have been connected with car lighting work for some time know that in the early days pasted type plates were used more or less extensively. These plates, however, did not seem to be able to stand up in this service and usually went to pieces after a life of but one or two years.

There is probably no question that one of the chief reasons which contributed to the failure of pasted type plates in car lighting service was the severe conditions of overcharging which usually maintained in axle generator service up to three years ago, and as experienced car lighting men well know, this overcharging was often carried to such an extent that the battery became actually hot. A pasted plate cannot stand high temperatures nearly so well as plante type plates and it is largely for this one reason that the plante plates have been found to give longer life in the service than pasted type plates.

The successful operation of a vast number of pasted plate batteries in automobile service conclusively proves that the failure of the pasted type of plate in car lighting service was not due to the conditions of vibration and mechanical abuse but rather to the electrical conditions experienced in this service, for undoubtedly a battery mounted on a motor truck receives far more severe vibration than one mounted on a coach or Pullman.

It is interesting to note the results which have been obtained by one manufacturer in an attempt to make the pasted plate meet the conditions of train lighting service as they existed five years ago.

This battery was made up with plante type negative plates and with duplex or twin plate positives, each plate of the positive group being a double plate made by spot burning two thin pasted plates together, as shown in Fig. 1. Each pair of plates are separated by about 1/8 in. and the edges burned together at four points, this being sufficient to hold the plates in proper position and still allow free access and egress for the acid entering or leaving the plate. As shown by the

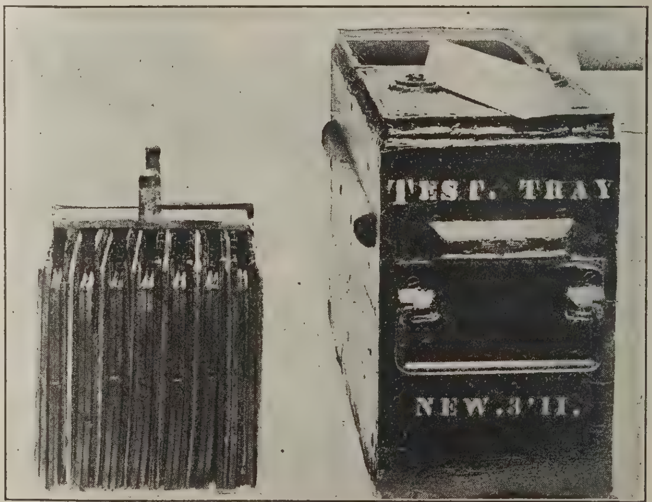


Fig. 1. View of Test Tray from Which the Duplex Plate Elements Have Been Removed, as Shown. Note That There Is a Very Slight Amount of Buckling and That One or Two of the Grids Are Cracked. Note That This Battery Was Placed in Service in March, 1911.

view of the test tray, Fig. 1, this test battery was placed in service in March, 1911. It was operated in connection with a U. S. L. type "C" axle equipment on a buffet car for 2½ years and was then transferred to a parlor car, where it was operated for 2 years more in connection with the same type of axle generator equipment. Therefore it may be said that this battery has received a fairly representative test. It has not been cleaned during the entire period of its operation; in fact, no attention was given it other than flushing. The original capacity test showed a capacity of 530 ampere hours and the present capacity test, made July 6, 1915, showed a capacity of 354 ampere hours. The cadmium test readings showed both positive and negative to be in healthy condition.

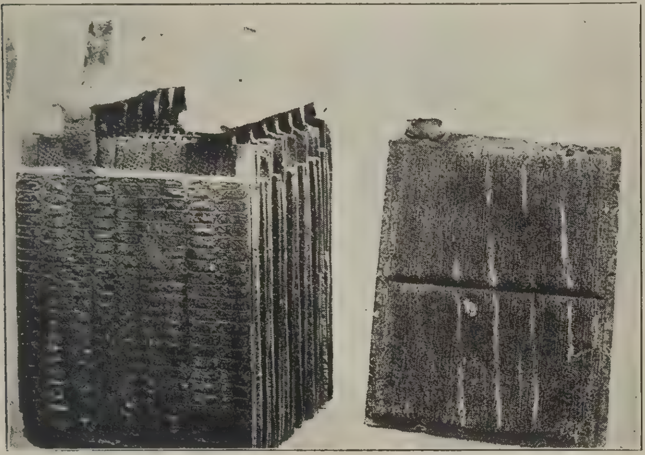


Fig. 2. Elements With Outside Negative Plate Sawed Off and Turned Around. Note the Lines of the Separator on the Negative, Also That Positive Grid Is Broken at the Lower Left Hand Corner. Positive Material Seems To Be in Almost Perfect Condition, Considering the 4½ Years' Service.

The condition of the plates of this battery are farily well shown in the accompanying illustrations, Figs. 2 and 3. In Fig. 2 the outside negative plate has been sawed off, so as to expose the surface of the adjacent positive plate, and the negative turned around so as to show its inside surface. It will be noted that both the positive and negative plates seem to be in a fairly good condition except that the grid of the positive seems to have failed, particularly at the edges where the cross ribs join the vertical rib at the edge.

In Fig. 3 one of the positive plates (not the first plate of Fig. 2, however), has been removed, sawed apart and opened, so as to show the interior surface of the positive plate. It will be noted that aside from numerous cracks in the active material, the plate seems to be in perfect condition and it should be stated in passing that the inside surface of this positive showed no sulphation whatsoever. The peculiar marks at the right and left hand edges were caused by the hack saw cutting the plates apart. It will be noted that there is a slight growth of material deposited on both plates, and this seems to have taken place almost altogether near the bottom. In these plates the grid was not broken at any point, although several other plates of the group were broken at the bottom corners and edges, as shown in Fig. 2. This is undoubtedly due to the fact that the grid of the plates in Fig. 3 is slightly heavier than that of Fig. 2. It will also be noted that the pockets are slightly larger.

The fact that the inside surfaces of the positive plates showed no signs of sulphation is a direct proof of the fact that the active material on these inside surfaces took part in the battery operation and was frequently charged and discharged, and this fact undoubtedly justifies making the plate as a double plate instead of one solid thick plate, in which case it would be much more difficult for the acid to reach the active material deep down in the plate and sulphation at this point might occur.

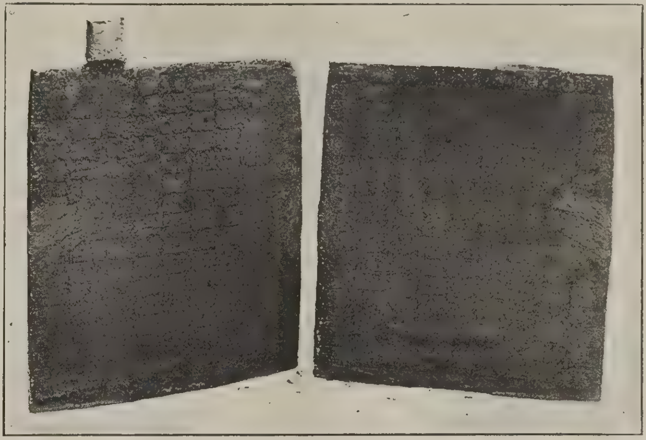


Fig. 3. A Duplex Positive Plate Split in Two and Spread Apart So as To Show the Inner Surfaces of the Plate. Note That the Active Material Seems To Be in Perfect Condition Except for Minor Cracks, Which Run for the Most Part Vertically Through the Buttons of Active Material. Mark at Right Hand Edge Is Caused by Saw Used in Cutting Plates Apart.

The active material on the inner faces of these plates may be likened to the reservoir of a pumping station and on discharge, although the current at first would be largely supplied by the active material on the outer surfaces of the plate, the interior surfaces would soon begin to furnish current, and even after the circuit had been opened, there would be an equalizing current which would continue to flow from the inner surface to the outer surface of the plates, thereby slightly recharging the active material of the outer surfaces. This acts very much the same as when an undercharged battery and an overcharged battery are connected together in multiples, resulting in an equalizing current flowing between them until both batteries come to the same terminal voltage.

As the lamp current on the car in which this battery was used never was in excess of 35 amperes, but often operated for long periods at this full load value, the battery was never severely overworked in so far as discharged rate was concerned; in fact, this was well below normal rate. On charge, however, the battery undoubtedly received long overcharging at certain times, as has been so generally experienced in connection with axle equipments operated on the principle of voltage cutoff.

In the more modern types of axle lighting equipments, however, which employ the taper charge principle or the ampere hour meter control of battery charge, this severe overcharging which so seriously affected the pasted plate battery in the earlier days, is now greatly reduced, if not entirely eliminated; accordingly, it is to be expected that the pasted type plate will come into more general use for car lighting on account of its lighter weight and cheapness of construction.

Pennsylvania Suburban Electrification

The Pennsylvania Railroad will soon put into commercial operation the electrified portion of the main line from the Broad St. station in Philadelphia to Paoli. This electrification has been made at a cost of $4,000,000, a sum which would buy the right of way and build 400 miles of ordinary track—and is the most modern and efficient 20 miles of electrified railroad in the world. Almost the heaviest traffic in America passes over this stretch of railroad. Limited trains that link the east and west, as well as the heaviest of slow moving freights and scores of hurrying locals, pass over this branch. When it is realized that this had to be electrified without interrupting traffic, some idea of the difficulty of the task can be obtained. Between the Broad St. station and West Philadelphia the traffic is especially concentrated. On this six track portion there are 55 switches and 52 signals and no less than 2,295 separate movements of trains and engines occur daily.

In order that there may be no hitch in operation, due to the change from steam to electricity, the crews have been going through a course of training for some time. Motormen and crews have been receiving daily drills in the operation of the new electric trains. Six hundred men in all have been undergoing careful instruction. For this purpose two instruction cars have been fitted up, one at Broad St. station and the other at the West Philadelphia shops. Every man assigned to the electric train service or to the reserve is required to pass an examination on the operation of the new trains.

A technical description of this electrification will be given in a subsequent issue of the Railway Electrical Engineer so no attempt will be made at this time to describe the apparatus and equipment except in a general way.

Some Notable Achievements.

Certain of the problems encountered in planning the work of electrification had to do with signals. The result was that an entirely new automatic block signal system differing from any type previously used in railroad work was invented. A new form of electric motor was devised which differs in important features from all others heretofore used and is expected to prove the most efficient railroad car motor yet constructed. The work of electrifying this 20 miles of railroad involves the stringing and restringing of 660 miles of electric wires, the erection of 760 poles, 36 signal bridges, and 4 power sub-

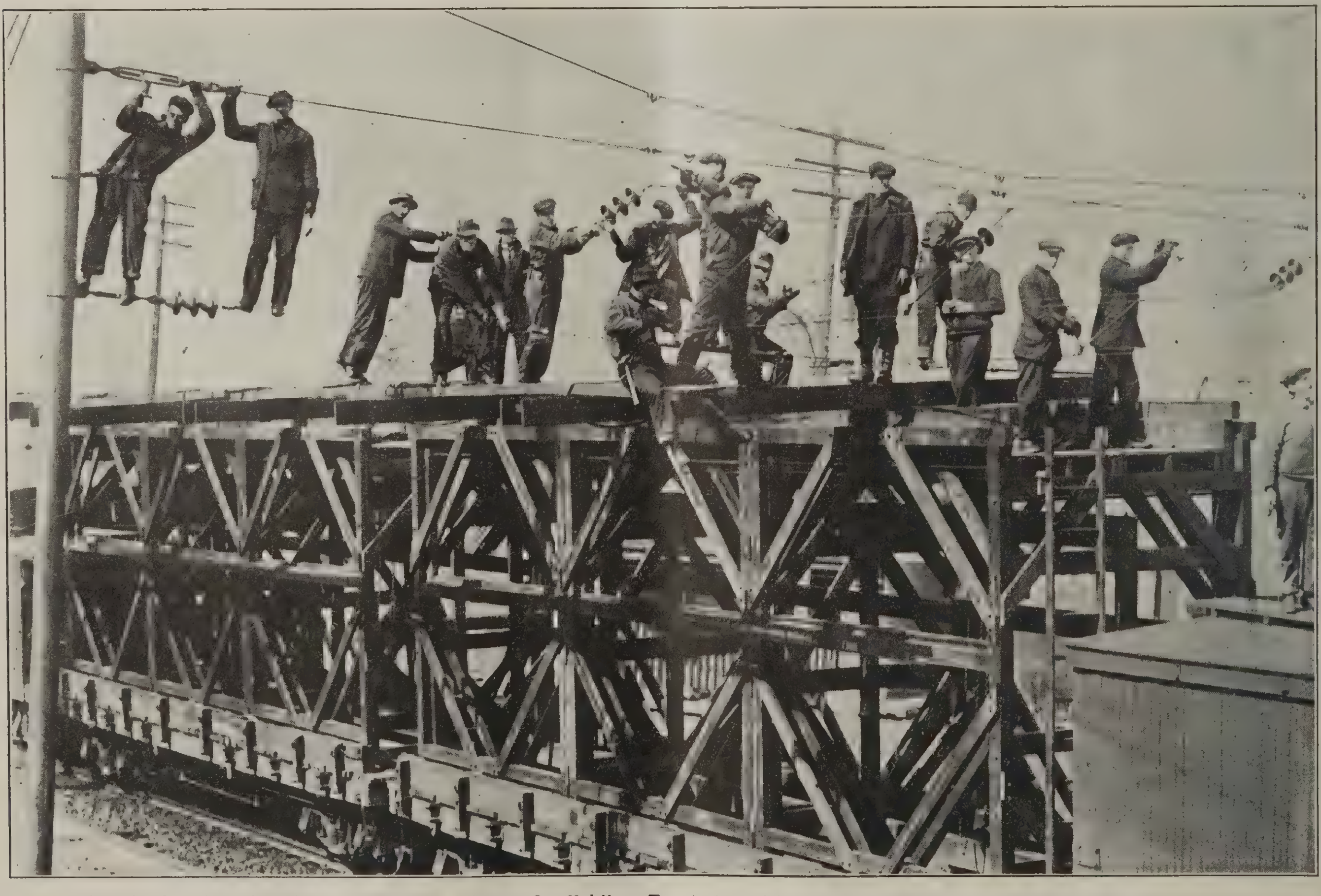


Fig. 1. Electric Construction Gang at Work. Strong Scaffolding Erected on Flat Cars Brings the Men Up To the Level of the Wires. Large Gangs of Men Were Employed So as To Block the Track for as Short a Period as Possible.

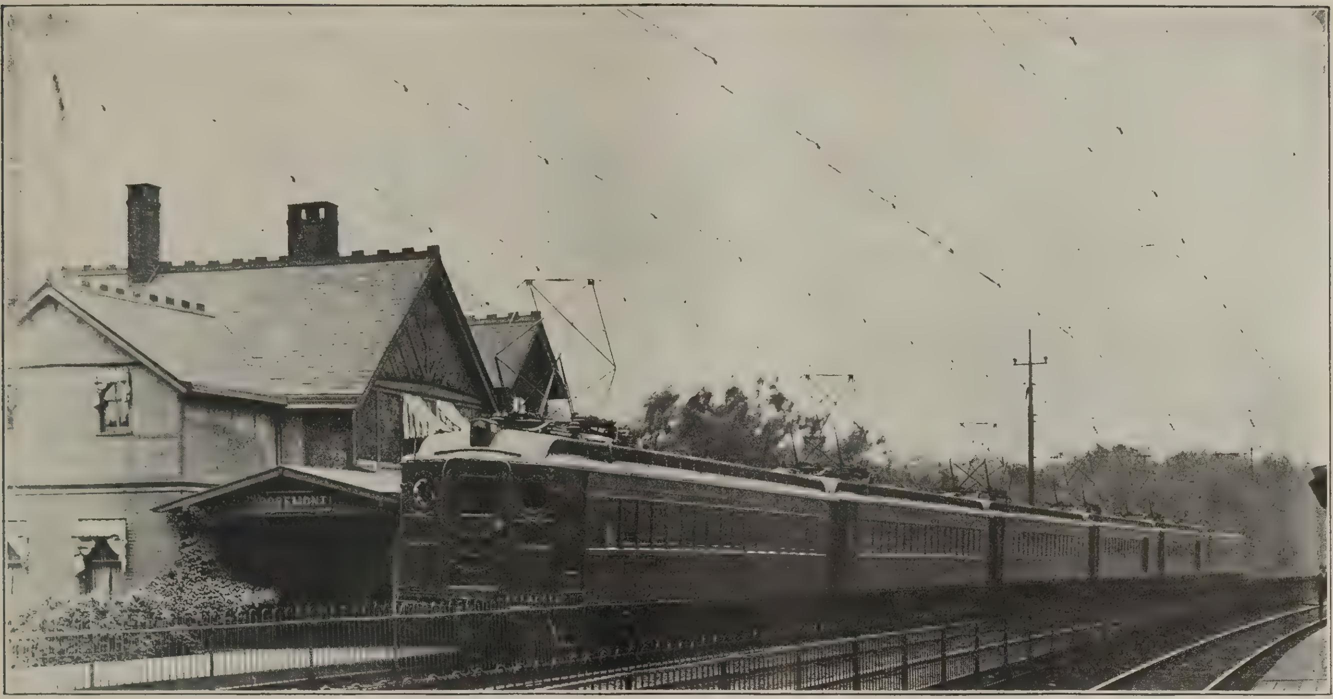


Fig. 2. Suburban Train at Rosemont. This Is the Type of Train That Will Operate Between Broad Street Station, Philadelphia, and Paoli.

stations. This was accomplished without the loss of a single life or the occurrence of any serious accident from electric shock, which is a record without a parallel in a job of these proportions.

What the New Electrification Will Accomplish.

The direct money saving to the company will probably be small, perhaps no more than enough to pay the interest on the cost of the work. It will result, however, in increased efficiency and will add materially to the traffic handling capacity of Broad St. station, resulting in a mutual benefit to the public and company.

Broad St. station is what is known as a "stub" terminal. A steam train after arriving cannot leave the station until a fresh engine, headed in the proper direction, backs in from the yard to what was previously the rear of the train. Any change in the train necessitates hauling it to the yard and there breaking it up and reforming it. With electric trains, most of this lost motion will be taken up as, trains can move in either direction. All that is needed to reverse an electric train is for the motorman to walk from one end to the other and start back on the return trip. This increases facility in train handling, will reduce train movements by about 15%, and it will cut down the time during which the suburban trains

Fig. 3. Men Lining Up the Trolley and Hangers. This Was a Familiar Sight During the Progress of the Work.

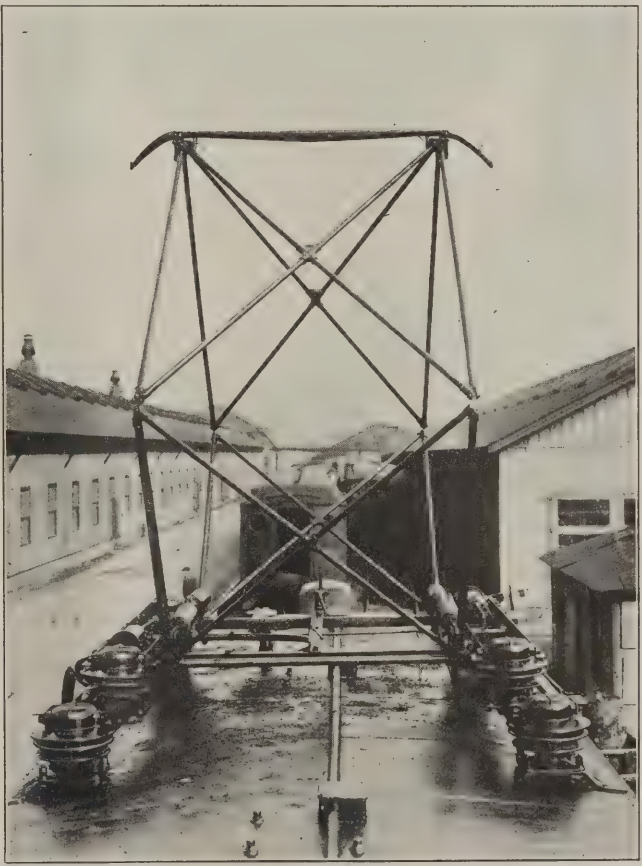


Fig. 4. A Close Range View of a Pantograph. Note the Large Insulators on Which the Pantograph Rests.

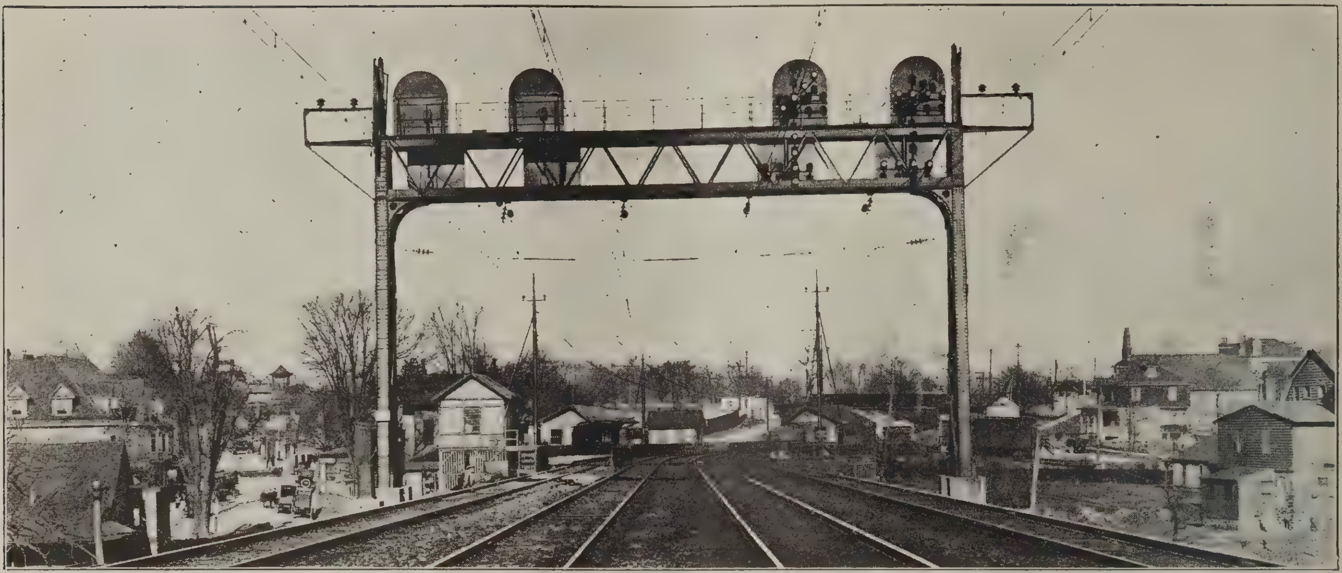


Fig. 5. The New "Position Light" Automatic Block Signal. The First Signal Is Set, "Proceed With Caution," and the Second, "Stop" (Block Ahead Occupied). Each Signal Protects a Block 3,500 Feet in Length and Notice of a Possible Stop Is Given at Least 7,000 Feet in Advance.

occupy the terminal tracks in the station proper. This will be another important aid to the prompt handling of passenger traffic at Philadelphia.

As is already well known, the secret of increased speed with an electric train is due to its ability to accelerate and stop in less time. Between Broad Street Station and Paoli there are 19 stops in a distance of 20 miles. To maintain this schedule it is necessary to use very heavy and powerful locomotives with small trains of 3 to 8 cars. A local train running with steam power between these two stations is practically starting or stopping throughout the entire run. With the type of electric trains which will be used on this section, each car has its own motor and a long train can accelerate as quickly as a single car.

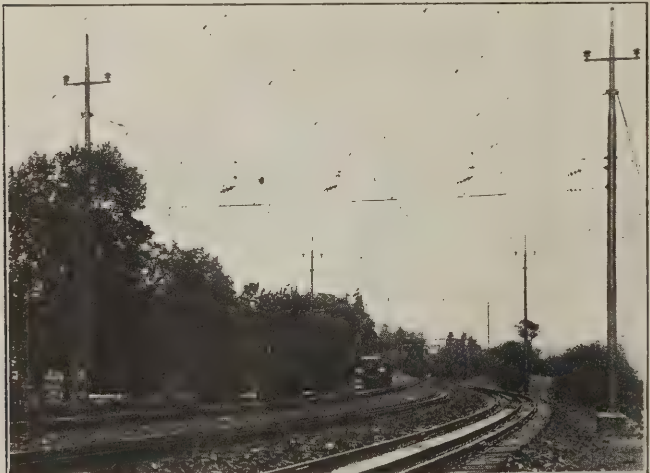


Fig. 6. Philadelphia-Paoli Electrification. This Shows the Catenary Construction for Curved Track With Its Graceful, Sweeping Lines.

The New Signal System.

The new automatic block signal system which has just been installed is, as has been stated, a distinct departure from any other type of signals heretofore used on American or foreign railroads. All moving parts have been eliminated from the signals themselves and there is no delicate machinery mounted on the signal bridges to get out of order or require attention.

A most valuable feature of the new system is that the same signals will be used day and night and the motorman and engineman will be guided by the same code every hour in the 24. The principle of the new signals is the use for both day and night of rows of brilliant white electric lights shown in sharp relief against a black background. These replace the moving arms of the semaphores used by day and the colored lights used by night in the ordinary forms of signal systems.

Lights Duplicate Semaphore Positions.

The lights of the new signals are so arranged that by lighting the proper row in position of the semaphore arms, horizontal, diagonal or vertical, can be duplicated. Each signal is equipped with a sufficient number of lights to be the equivalent of two semaphore arms. To make the lights clearly visible even against the brightest sunlight, the current used in the day time is nearly four times as powerful as that used at night. It is possible to see these lights even in the brightest sunshine for more than 4,000 ft. With night conditions they are so bright that it is possible to read large type by their light at a distance of 1,000 ft.

Each signal protects a block of track about 3,500 ft. in length. A train passing a signal automatically sets it at "Stop." This is a warning that there is a train somewhere in the block behind the signal. When the first train passes out of the block the signal at the entrance of the block automatically changes to "Caution." The caution signal always means one block ahead is clear, but the next one occupied. The third position of the signal lights shows when two full blocks ahead are clear and a fourth position, when three or more blocks are unoccupied. Under this arrangement a motorman always receives notice of a possible stop at least 7,000 ft. in advance, and always receives at least two cautionary signals before approaching a stop or danger signal.

The new signals are mounted on structural steel bridges which span the track and serve the additional purpose of anchoring the trolley wires.

Electric Locomotive Performance on the Pennsylvania Railroad

Some very interesting figures have just been given out covering the performance of the electric locomotives used by the Pennsylvania Railroad on the Manhattan Division, operating passenger trains through tunnels entering New York City under Hudson River. This project has been noted at various times in the Railway Electrical Engineer.

These locomotives have been in use for nearly four and one-half years and the data given below represents their performance during the period in a very striking manner.

They were designed to start and accelerate a 550-ton train, in addition to the locomotive, on a 1.93 per cent grade in tunnels, but in actual operation, 850-ton trains are frequently started on this grade and trains of 14 all-steel cars, weighing over 1,000 tons, are handled without difficulty.

Each locomotive in service passes over an inspection pit every 24 hours, when a running inspection of machinery is made, similar to that given steam locomotives over the pit, and slight repairs made where necessary. The average time required for this inspection is approximately ten minutes.

After 3,000 miles run, the locomotives are taken into the shop for a general or periodic inspection, when all electrical apparatus is thoroughly gone over, tested, cleaned and necessary adjustments and renewals made to all electrical and mechanical parts.

The shopping of these locomotives for general repairs is governed by tire wear, and a number of locomotives have run from 90,000 to 112,000 miles before it was necessary to turn the tires or do any general repair work.

The general overhauling and repairing of these locomotives is done in one of the regular steam locomotive repair shops.

On November 28, 1914, these 33 locomotives had completed four years' service, and during that period the mileage made and detention record is as follows:

Locomotive-miles	3,974,746
Total Engine Failures	45
Total minutes detention to trains	271
Locomotive-miles per detention	88,328
Locomotive-miles per minute detention	14,667

During this period, 463,588 train movements were made, or an average of 1,300 movements per detention, due to engine failures.

Typical Train with Electric Locomotive Running Into New York Under Hudson River.

At Manhattan Transfer, where the change is made from steam to electric locomotive, on trains to and from the Pennsylvania station, the time allowed per schedule for making change, including necessary testing of air brakes, is four minutes; although the entire operation can be performed in three minutes, and has been done in two minutes.

These locomotives are articulated machines, each consisting of two semi-units permanently coupled together, each semi-unit having a four-wheel bogie-truck and two pairs of driving wheels connected by siderods, the semi-units being permanently coupled together at the driving wheel end. The locomotive frame, driving wheels, trucks and running gear are similar in general character to the standard American type steam locomotive and the relation of the various working parts on the two semi-units is similar in location to two steam locomotives coupled back to back.

Each semi-unit is equipped with a 2,000-horsepower motor connected to the driving wheels through a system of parallel rods and cranks with an intermediate shaft, and is fitted with unit switches, master controller, Westinghouse automatic and straight air brake apparatus, electric headlight, pneumatically operated whistle, sand apparatus and other items of lesser importance. The locomotive equipment is so arranged that in the event of one motor being cut out of service, the entire locomotive can be operated from the other cab with the remaining motor. The unit switch control permits two or more locomotives to be coupled and all to be operated from either end of any one cab. The semi-units are interchangeable, and if any two semi-units are separated, they can be combined with any two other semi-units, as may be required in making repairs, or for other reasons. The controllers are fitted with four running notches, giving great flexibility of speed regulation, and permitting the most economical use of power during acceleration.

Each motor has a continuous rating of 1,000 and a maximum rating of 2,000 horsepower, or a total of 4,000 horsepower per locomotive. The motors are of the direct-current, field-controlled commutating-pole series type. The weight of each motor complete, including cranks, is 43,000 pounds. The motors are supplied with direct current at 650 volts from the third rail, through contact shoes, located on either side of each truck. The motors, control and the complete electric equipment was furnished by the Westinghouse Electric and Manufacturing Company, while the locomotives were built by the Pennsylvania Railroad in its own shops at Altoona.

The rated tractive power of each locomotive is 66,000 pounds, but in actual service 79,200 pounds has been registered.

Pennsylvania Locomotive, Showing Running Gear.

Weight and Dimensions.

Weight of locomotive complete	156.5 tons
Weight per driving axle	49,750 lbs.
Total weight on drivers	199,000 lbs.
Weight on each truck	57,000 lbs.
Total length overall	64 ft. 11 in
Rigid wheel base of each semi-unit	7 ft. 2 in.
Total wheel base of each semi-unit	23 ft. 1 in.
Total wheel base of each locomotive	55 ft. 11 in.
Total height of locomotive	14 ft. 8 1/8 in.
Total height of cab	13 ft. 1 1/16 in.
Total width of cab	10 ft. 8 1/4 in.
Diameter of drivers	72 in.
Diameter of truck wheels	36 in.

Electrification of Terminal Line at Great Falls, Mont., Chicago, Milwaukee & St. Paul Ry.

As an undertaking related to the forthcoming electrification of its main line between Three Forks and Deer Lodge, Mont., the Chicago, Milwaukee & St. Paul Ry. has recently installed electric motive power on its terminal line in the city of Great Falls, Mont. This city is at present the terminal of the new 138-mile branch line from Lewistown, Mont., connecting with the main line transcontinental division at Harlowton. The latter city is the eastern terminus of the 3,000-volt electrification now under construction. The Great Falls and the terminal yards are connected by a crosstown line, about 4 miles in length, known as the Valeria Way line. There are about 3 miles of additional electrified trackage, making a total of 7 miles. The terminal buildings include a large freight house, roundhouse, power plant and passenger station.

The tracks connecting the Falls yards and the terminal yard pass through the business part of the city; and it is expected that considerable benefit will be derived from the elimination of steam locomotive smoke from the center of the city, as well as a reduction in the cost of train haulage. The traffic includes the transfer of both freight and passenger trains from the Falls yards to the terminal station, as well as swtiching service in the terminals.

The electrical equipment is of sufficient capacity to take care of 580-ton freight trains operating at about 9½ miles per hour on the maximum grades of 0.65 per cent. Electric power is supplied by the Great Falls Power Co. from the hydroelectric plant at Rainbow Falls, about 6 miles from the substation. Energy is transmitted at 6,600 volts, 3-phase, 60 cycles, as generated at the power station.

Substation.

The substation equipment is located in the power station operated by the railway for heating the terminal buildings. It includes a 2-unit, sychronous motor-generator set with a two-panel switchboard for controlling the alternating and direct current units. The motor is rated 435 kva. (0.8 power factor), 6,600 volts, and operates at 900 revolutions per minute. Provision is made for starting as an induction motor through a compensator, which is operated from the alternating current panel. The generator is the commutating pole type, rated 300 kw. at 1,500 volts. The set is capable of carrying 200 per cent overload, or 900 kw. momentarily. Excitation for the alternating current motor fields and for the shunt fields of the direct current generator is furnished by a 10-kw., 125-volt, direct-connected exciter.

The switchboard consists of two natural black slate panels, one controlling the sychronous motor and the other the direct current generator and feeder. The direct-current panel is a standard 1,500-volt type, carrying remote control, hand-operated switch and circuit breaker mounted between slate barriers at the top of the panel. The motor panel contains the usual instruments and starting and operating switches for controlling the motor. An aluminum cell lightning arrester is also installed in the station as a protection against electrical storms.

Locomotive.

All trains are handled by a standard, 50-ton electric locomotive of the steeple cab type, designed for slow speed freight and switching service. The running gear consists of two swivel equalized trucks, carried on semi-elliptic equalizer springs. The driving wheels are of solid rolled steel, 36 ins. in diameter. The motor equipment includes four GE-207, 750-volt, box-frame, commutating pole motors insulated for 1,500 volts. Each motor has a normal one-hour rating of 79 h. p. at 750 volts, and two motors are connected permanently in series. All motors are ventilated by a blower direct-connected to the dynamotor in the cab of the locomotive. The gear reduction is 64 to 17.

Type of Locomotive Used for Freight Hauling on the Electrified Terminal Line at Great Falls, Montana, Chicago, Milwaukee & St. Paul R. R.

The control equipment is Sprague General Electric type M, arranged for operation from either end of the cab. There are ten steps with the motors in series and seven steps in series-parallel. Control current for operating the contactors, lighting and other auxiliary circuits is furnished by a type CDM-19, 1,500/600-volt dynamotor. A multivane fan carried on an extension of the shaft furnishes air for ventilating the motors.

The current collector is a sliding pantograph, similar to that being installed on the main line 3,000-volt locomotives. The slider is lifted into position by air pressure and is held against the wire by steel coil springs. Provision is made for operating at trolley heights varying from 17 to 25½ ft. above the top of the rail.

Compressed air for operating the air brakes, whistles and sanders is supplied by two CP-29, 1,500-volt, motor-driven air compressors. Each of these units has a displacement of 27 cu. ft. of air per minute at 90 lbs. pressure. The compressors are located in the cab of the locomotive convenient for inspection.

A headlight, provided with a concentrated filament type Mazda lamp of about 100 c. p., is mounted on each end of the locomotive.

As a safety precaution, no trolley wire is installed inside of the roundhouse. A connection is made in the locomotive for applying power to the locomotive through a length of special flexible cable insulated for 2,400 volts. A double-throw switch in the locomotive cab allows connection to be made either to the trolley or cable circuit.

Line Construction.

The overhead line construction is of the catenary type, similar in a general way to that installed on the Butte, Anaconda & Pacific 2,400-volt railroad. Both span and bracket construction are used, depending on local conditions. Poles are spaced approximately 150 ft. apart on tangent track, supporting a 4/0 grooved trolley from a 3-point suspension. There is no feeder copper installed.

The work was done by the electrification department of the Chicago, Milwaukee & St. Paul Ry., R. Beeuwkes, engineer-in-charge, under direction of C. A. Goodnow, assistant to the president. All of the electrical apparatus, including locomotive, substation equipment and line material, was furnished by the General Electric Co., Schenectady, N. Y.

Effective Resistance and Inductance of Iron and Bimettalic Wire.

When a direct current flows in a wire, the distribution of the current is uniform over the cross-section of the conductor. When, however, an alternating current flows in a wire there is a tendency for the current to crowd to the outside. This phenomenon which is caused by differences in the opposition to the current flow in different part of the conductor, becomes more pronounced the greater the number of alternations of the current in a given time and, in iron wires, the greater the current in the wire. In some cases the flow of current is confined almost entirely to a thin shell on the outside of the wire and hence arises the term "skin effect" for this phenomenon. The effective resistance of the conductor increases as the frequency of the alternations increases and at the same time the inductance, which depends upon the magnetic field, is diminished. This effect is not only of interest from a purely scientific standpoint, but is frequently of importance in engineering practice.

When the conductor is of simple form and the magnetic permeability of the material is known, the effective resistance and inductance can be calculated by formulas which have been developed. The investigation, the results of which have just been published by the Bureau of Standards, Department of Commerce, in Scientific Paper No. 252, was concerned with the skin effect in conductors containing iron. Two classes of conductors were considered in particular, the iron telegraph and telephone wires and copper clad bimetallic wires. The latter have a core of steel surrounded by a shell of copper. The effective resistance and inductances of these conductors were determined experimentally for different strengths of current and for frequencies up to 3,000 alternations per second. The results for iron wires obtained with very small currents were compared with values computed by known formulas and the agreement is fairly satisfactory. Formulas are developed in this paper which permit a similar comparison between measured and computed values for the copper clad wires. The paper concludes with wire tables computed by means of the new formulas. In these tables the effective resistance and inductances of copper clad wires are given for wires of different sizes and conductivities and for frequencies u to 3,000 alternations per second.

Interested parties may secure copies of this pamphlet free of charge by applying to the Bureau of Standards, Washington, D. C.

Shop Motor Section

Starting of Squirrel Cage Induction Motors

J. H. Wickman

Eighth Article

As a general rule polyphase motors in sizes over 5 h.p. are equipped with some type of auto-starter or compensator for starting purposes. This is necessary, for otherwise the starting current might be several times larger than the normal full load current which would set up severe line disturbances and might do considerable harm. The maximum power demand is often taken into consideration by the contracting parties when buying and selling power, in adjusting the rates.

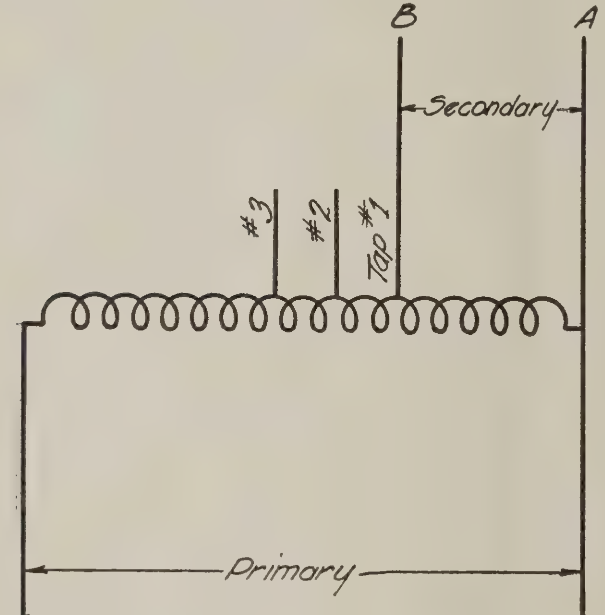


Fig. 18. Sketch Showing Principle of Auto Starter.

The starting torque of an induction motor, which is the turning moment expressed in foot pounds, is proportional to the square of the voltage applied to the stator windings and also depends on the resistance of the rotor. It usually varies from 2½ to 3 times its torque at full load, according to the design. For this reason the voltage applied to the stator windings can be considerably reduced and the motor will start the load, drawing no more than full load current from the supply lines.

An auto-starter may then be defined as a device for reducing the voltage applied to a motor during the starting period. The principle of operation of one type of starter is shown in Fig. 18. The whole coil represents the primary coil which is connected across the line, while the secondary part A. B. forms the secondary and is connected to the machine which is to be started. The diagram shows the connections which would be used with a single phase auto-starter and while these are not extensively used commercialy, the principle applies to polyphase auto-starters. The latter being merely a combination of 2 or 3 one phase auto-starters properly connected together.

Fig. 19 shows a diagrammatic sketch of the connections and operating principle of an auto-starter manufactured by the General Electric Company for use with a three-phase motor. It will be noted that the three leads from the supply A-B-C are connected in a star through the neutral "N." When the handle is placed in the starting postion the connections represented by the six dotted lines between the drum and the starting side are made and the motor receives a proportional part of the line voltage through the taps marked 2. Two or three other taps are generally provided so that if the motor does not start on one voltage the connections can be moved to one of the other taps, as shown by the numbers 1 and 3. The highest starting torque is obtained when the connections are made to taps 1. When the handle of the compensator is thrown into the running position the connections shown by the dotted line are all broken. "G" is connected to D; "H" to E and F to I, this would connect the motor directly to the supply lines. In Fig. 19 it will be noticed that fuses are shown on the running side of the starter, while the starting side is connected from the main, which would require a much larger capacity fuse.

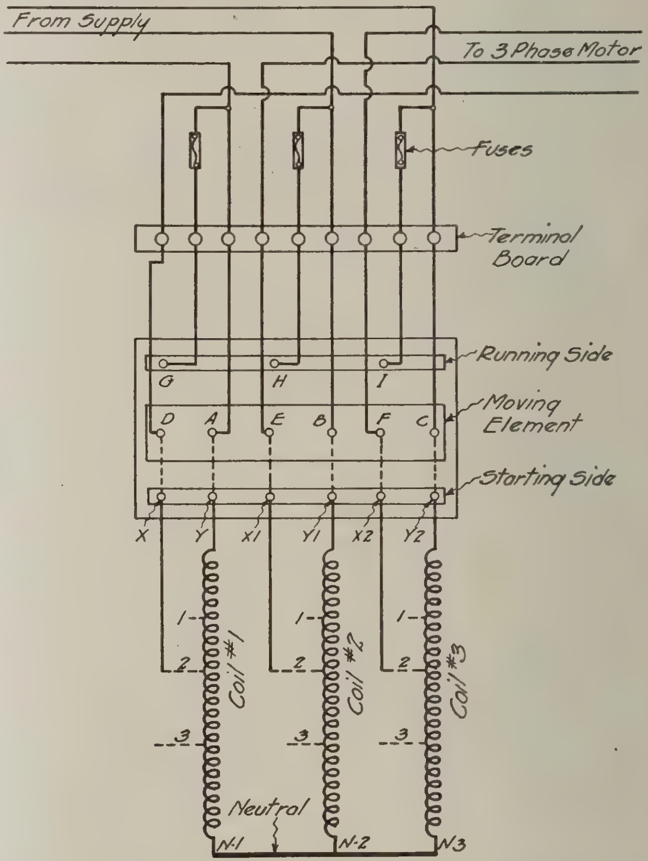


Fig. 19. Diagrammatic Representation of the General Electric Company's Compensator.

Two of the principle troubles which occur with starters of this type are, first, fingers and contact plates burn off, caused generally by frequent starting or by "touching," that is, putting the handle in the starting position several times to move the rotor just a little, as is often done in lining up machines or tools. This trouble is easily remedied by replacing the burnt parts with new ones. Second, the coils may be burned out. If extra coils are not on hand to replace the burnt coil, the damaged coil can be cut out of the circuit entirely. This may be done as follows:

To cut out coil No. 1, open the connections at N-1, X and Y and connect the terminals X and Y together.

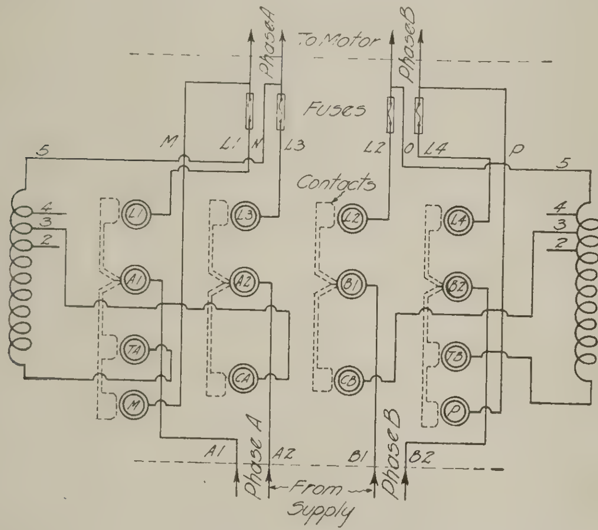


Fig. 20. Wiring Connections of a Westinghouse Type "B" Auto Starter.

the stator when starting and to increase the starting torque. For this reason three-phase auto-starters with 3 coils are preferable to those having but 2, for if one coil burns out of a 2-coil starter and no extra coils are on hand, the starter could not be used. In Fig. 20 is shown a Westinghouse type "B" auto-starter with connections for two phase. This starter may be adapted for three-phase work as well as by connecting the leads A-1 and B-2 together on the motor side and L-1, M, P, and L-4 on the line side. The leads C, A and C, B should be connected to which ever of the taps 2, 3 or 4 is required to give the requisite starting torque to bring the motor up to speed. The starting torque with each top is proportional to the number of that tap. To cut out coil No. 2, open the connections at N-2, X-1 and Y-1 and connect the points X-1 and Y-1 together. Likewise in cutting out No. 3, open the connections at N-3, X-2 and Y-2 and connect the terminals X-2 and Y-2 together. When one coil is cut out in this way the effect is to increase the voltage across The leads C, A and C, B should always be connected to the same numbers on both coils A and B, otherwise an unbalanced phase voltage will be produced in the starter.

Several types of starters introduce resistance in series between the motor winding and the supply, the starters operating as they would on direct current, the resistance being cut out step by step. The objection to this type is, however, the excessive burning of the contacts when breaking the circuit. As they do not find extensive commercial use they will not be described here.

There are a large number of auto-starters or compensators on the market but most of them operate upon the principle of those shown in Figs. 2 and 3. With these a squirrel cage induction motor has a fractional part of the line voltage impressed across its terminals until it is up to speed, when the full line voltage is applied to the machine. This type of starters therefore is only used with uni-speed motors. The methods of controling the speed of alternating current motors where the variable speed drive is desired, will be taken up later.

Oil for Starters.

Special attention should be given to the transformer oil used for filling auto-starters. This should be tested for moisture, conductivity and cleanliness. A very small percentage of moisture will greatly reduce the insulating qualities of this oil, 1% moisture reducing the insulating qualities 11%. By passing the oil through slacked lime, dry sand or straw a number of times and then straining it through a fine mesh cloth, the moisture can be almost entirely removed. After several contact tips and plates have burnt off in the coil a copper and brass sediment will form in the bottom of the tank, the color of the oil will be changed and the quality deteriotates, indicating that the oil should be replaced. The old oil may be filtered and used over again. As already has been pointed out, this sediment increases the conductivity of the oil and may cause serious burn-outs.

The Principles of Alternating Currents

Williard Doud

Fourth Article

In the preceding installments of this series illustrating the action of alternating currents, the general characteristics of single phase, two phase and three phase currents were explained by means of diagrams and by comparison with hydraulic pumps having different arrangements of cylinders, piping and operating mechanisms.

In following out the discussion it was assumed, purposely, that the flow of alternating currents did not differ from that of continuous or direct current. With the passage of continuous current through a circuit from a direct current generator, the intensity of voltage or pressure and current or rate of flow at any instant in the generating cycle, have corresponding values both as regards direction and intensity and as a result the current and voltage were assumed to be what may be termed, "in step."

In the hydraulic analogies used for direct, single, two and three phase currents the liquid inside of the piping connecting the cylinders and corresponding to the external circuit or distribution wires, was treated as a solid or incompressible fluid which followed unhindered the direction and speed of the piston through the entire stroke or revolution without variation.

With a direct or continuous current flowing through a wire, practically the only hindrance to its free movement, assuming no portion of its energy is expended in doing useful work, is the resistance of the circuit conductor to its passage.

The flow of alternating current through a wire is affected by considerations in addition to conductor resistance, and in the following an explanation will be made by use of diagrams and hydraulic analogies of the factors which enter into the retardation of current in a conductor and which do not allow of application without modification the elementary formula for direct currents, $C = \frac{E}{R}$ and its various modifications $E = CR$ and $R = \frac{E}{C}$.

The principal obstacles to the free flow of alternating currents, neglecting resistance, are inductance and capacity.

Inductance.

Inductance is a counter or opposing voltage set up in a circuit as the result of an increase or decrease in the current; this inductive voltage lags behind the impresed voltage by 90°.

In the application of the hydraulic analogy to the explanation of inductance, the liquid flowing through the pipe which represents an electric current, must be considered as an *elastic* and not an incompressible medium.

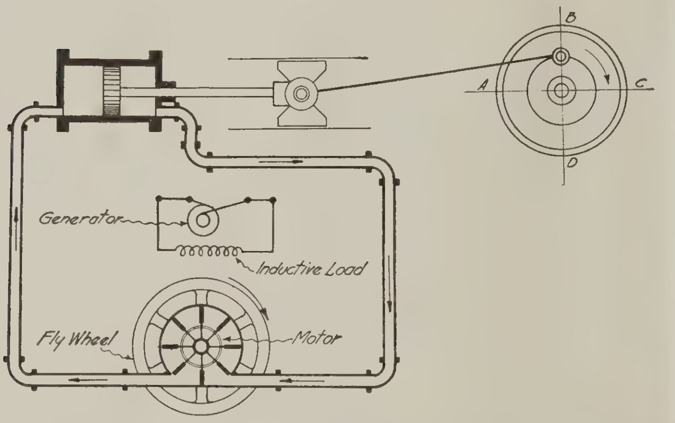


Fig. 18. A Simple Pump With Frictionless Motor in Circuit Representing Inductance. A Similar Electric Circuit Is Shown Inside of the Pipe Loop.

Fig. 18 shows a single cylinder pump, the ends of the cylinder being connected together and in the piping placed a frictionless motor operating a heavy flywheel which is actuated by the liquid flowing in the pipe. For comparison, a wiring diagram is shown with a coil of wire or inductive load in the outside circuit which corresponds to the fluid motor and flywheel.

If a current is suddenly started in one direction through the piping, it will not take on the same rate of flow at all points in the pipe system until the speed of the motor wheel or impeller assumes the same speed as that of the liquid. This is due to the fact that energy must be expended in starting and bringing the flywheel up to normal speed. When the motor and pipe line are subjected to an alternating flow of liquid from the pump it is evident that the motor will not reverse and consequently the liquid will not flow in exact accord with the piston in the cylinder. The speed and direction of the piston determine the value and direction of the pressure and the amount and direction of current or liquid that will flow through the pipe will depend on the pressure produced and on the inertia of the flywheel. So it is evident that the maximum flow of liquid will not occur at the same time that the maximum pressure is applied, but will have a tendency to lag behind. If the pipes offered no resistance to the flow of the liquid then the maximum flow would be one-fourth of a cycle behind the maximum pressure. It must not be forgotten that in order to produce this condition the fluid must be elastic or compressible in nature.

In the same way when an alternating pressure, or E.M.F. is impressed on a coil of wire the stored energy of the magnetic field about the coil will continually oppose the changing voltage which tends to change the value and direction of the current. The amount of the inductance depends on the characteristics of the coil. Iron in the core generally increases this effect.

Following the pressure analogy it will be evident that the current in the piping is forced back and forth by the combined action of the piston in the cylinder and the action of the vanes of the motor impeller. The latter force combined with the original impulses reduces the current, forcing it out of step or phase with the original impulses. The energy of the system is thus divided into two parts, one of which overcomes the friction or resistance of the liquid and is lost and the second is used to overcome the stored up energy or inertia of the flywheel and is returned to the system during the same cycle. The opposition of the impeller vanes of the motor to the flow of current, when a reversal suddenly occurs serves to store up fluid pressure which reacts and assists in starting the flywheel rotating in the opposite direction.

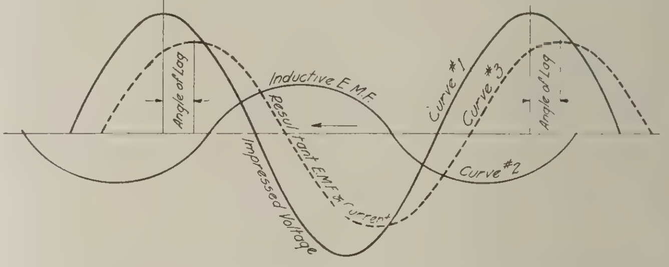


Fig. 19. Series of Curves Showing the Values of the Impressed or Actual Voltage in an Inductive Circuit, Counter E. M. F. Due to Inductance and the Resultant of These Two Forces.

The energy thus returned to the system may be termed the idle component for it is alternately given up by and returned to the generator. The energy used in overcoming resistance is the useful or working component.

In a coil of wire on which the alternating E.M.F. is impressed, one portion of the energy is absorbed by the circuit resistance and is dissipated as heat. This is expressed as watts and corresponds to the useful or working component in the hydraulic analogy. The other portion is absorbed as magnetic energy and returned to the system out of step with the original impulses and is the wattless or idle component of the total energy in the circuit.

The current in a circuit containing inductance is always in step or phase with the voltage or E.M.F. which is consumed in resistance and what is known as the impressed E.M.F. is the resultant of the instantaneous values of E.M.F. consumed in resistance—and the counter E.M.F. due to the inductance of the circuit.

Fig. 19 is a series of curves showing the values of the impressed or actual voltage in an inductive circuit, counter E.M.F. due to inductance and the resultant of these two forces.

It will be noted that curve No. 3 is obtained by adding the sums of the value of curves No. 1 and No. 2 above or below the horizontal lines. This is similar in form but has lesser values than and lags behind that of the impressed voltage and leads the curve of counter E.M.F. due to inductance. The current is proportional to this resultant curve, therefore the current in an inductive circuit lags behind the voltage and has a lesser value than it would have if the voltage was similar to that of a non-inductive circuit.

The Railroad Electricians' Club

Edison Storage Battery Questions.

Continued from last month

Effect of High Temperature.

Q. 22. What is the highest temperature which the battery can stand without injury for (a) continuous operation, (b) short periods?

Ans. 22. 115 deg. F. is the maximum prescribed by the manufacturer for continuous operation. For short periods, however, the battery will stand much higher temperatures than this, in fact in many cases where a battery was on test with terminals short circuited the electrolyte has actually boiled, due to the heat of the extremely high current flow, but the manufacturer states the plates have not seemed to be in any way injured by this high temperature.

Renewal of Solution.

Q. 23. How often is it necessary to change the solution of an Edison battery, and what indication shows if a battery needs new solution before this time?

Ans. 23. The manufacturer recommends that the solution be changed every two years, although in some cases this may not be necessary. The gravity of the solution gradually decreases after months of battery operation; this is due to the electrolyte being carried off by gasing.

When the gravity falls to 1,160 at level, thoroughly diffused, it is the proper indication that the solution requires renewal whether the battery has been in service two years or not. On the other hand, at the end of the two year period the solution may show sufficiently high gravity but there may be impurities which have collected in the electrolyte in flushing which would require that the solution be renewed. Therefore, it is strongly advisable to either renew the solution every two years as the manufacturers request, or submit a quart sample of the electrolyte to them for test. If it is found necessary to renew before 2 years, there must be something wrong with regulation.

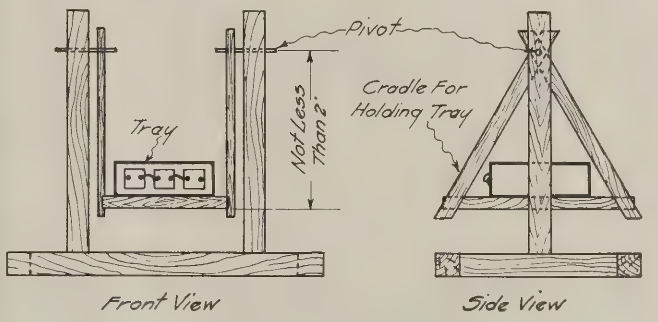
Method of Changing Solution.

Q. 24. What is the best method of changing the solution of an Edison battery?

Ans. 24. The battery should first be completely discharged, the cells should then be shaken so as to stir up any sediment that might be in the bottom, then open the gas vent cover and pour out the solution. Sometimes the solution taken from the cells is of a dark muddy color which indicates that a certain amount of sediment is removed from the bottom of the cells.

There are several methods of shaking the cells, one of which is to remove the connectors and take each cell out singly and shake it by hand, but where there is a large amount of this work to be done the following stunt may be made use of, with good results.

Suspend the battery tray either by a rope or wire from the ceiling and then shake. A more convenient way is, however, to construct a cradle as shown in the diagram below, which is pivoted at least 2½ feet from the trap support.



Cradle for Shaking Three Edison Cells at Once.

The last two stunts allow the entire tray, containing the three cells to be handled at once and by one man; it also permits the cells to be shaken more violently than by the hand method.

It is a peculiar fact that the gravity at the end of discharge is higher than at any other time. The exact reason for this cannot be stated but it would indicate that when in a charged or partly charged condition there is more or less of the soluble material of the solution which is being held within the plates and at the end of discharge this has been driven out of the plates into the electrolyte. Since in changing the solution, we desire to remove all of the old electrolyte, this can be done at the end of discharge after the electrolyte has been driven out of the plate.

Gravity of the Solution.

Q. 26. What are the limits of gravity for satisfactory operation of the Edison battery and when should a gravity reading be taken?

Ans. 26. The normal gravity of the solution is about 1.200 although in train lighting cells where so much space is provided for flushing, the gravity of the electrolyte will be considerably lower than this when the cells are filled and will be considerably higher than this when the level of the solution gets down near the top of the plate. Under these conditions the gravity should not go higher than 1.250 with the low level of solution, and 1.160 with the high level of solution. Immediately after renewing the solution the battery will probably show a gravity of 1.230.

It is of course impossible to get an accurate reading of gravity shortly after the battery has been flushed for the distilled water used in flushing is much lighter than the electrolyte, so remains at the top of the cell and in sample drawn off for testing gravity will have a large percentage of distilled water used in flushing and a small percentage of the electrolyte from the bottom of the cell. The battery should be charged until it gasses freely as this gasing will mechanically mix up the electrolyte so that a fair reading of gravity can be taken.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lessen No. 42

Gould Simplex System—Dismantling the Generator

Of course the extent to which a generator is torn down for inspection or repair would depend altogether upon what is necessary to be done, but in this lesson we will assume that the machine is to be all torn apart and the reader can then use his own judgment in performing operations necessary in his individual case of trouble.

Removing the Pulley.

Whether the machine is on its suspension or removed therefrom in the shop, as shown in Fig. 211, the pulley should be removed by applying a pulley puller. If a hammer and cold chisel is used for forcing off the pulley, this is liable to break the pulley flange and at the same time may spring the armature shaft. Therefore, the pulley puller should always be used. This is simply a steel yoke supplied with some means of gripping the pulley, and with a threaded rod for bearing against the armature shaft. The pulley puller as shown in Fig. 211, grips the pulley flange and a point on the end of the rod enters the shaft center. This is bad practice, as it is very essential that the shaft center should not be injured, and the pointed rod grinding into it will be very liable to mar the center. It will be found much safer to use a square ended block on the end of this rod, as shown in the bearing puller in Fig. 213. Some roads have this block recessed out so as to cover the end of the shaft and prevent its slipping and injuring the thread of the shaft.

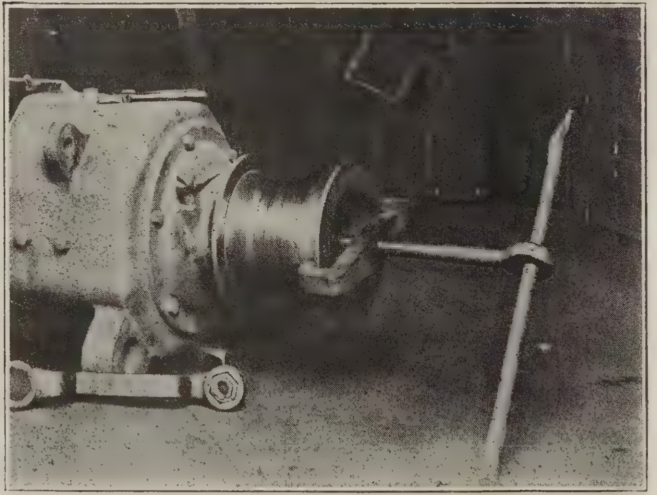


Fig. 211. Pulley Puller in Position. This Is a Poor Design of Pulley Puller as It Is Apt to Break the Flanges and the Pointed Rod Is Liable to Injure the Shaft Center. It Should Be Equipped So As To Grip the Web or Hub of the Pulley and Should Have a Square Ended Pressure Block on the Rod.

The grip on the pulley, as shown in the Fig. 211 is also bad practice, as this is apt to break the pulley flange. It would be much better practice to use T head bolts which could be passed through the slotted holes in the web of the pulley, or hooks that could be passed through the large holes in the pulley web. Another type of pulley puller, known as the "Consolidated," employs bolts which screw into tapped holes in the hub of the pulley.

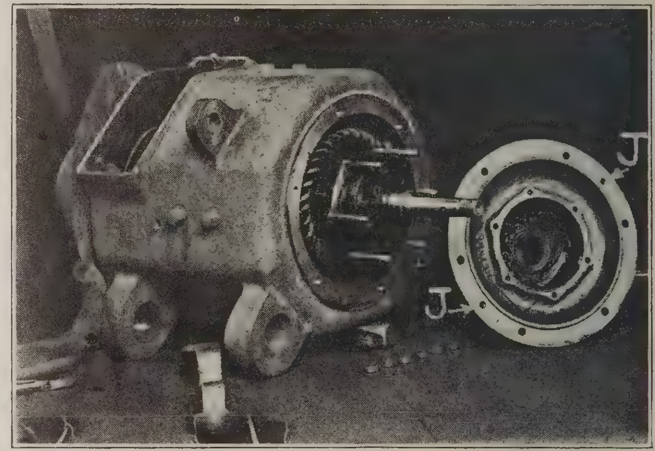


Fig. 212. Generator With Pulley End Housing Removed. After Removing the Six Cap Screws, and the Six Bearing Plate Nuts, Two of Them Are Screwed Into the Head at the Points "J" and Force the Head Off. If the Ball Bearing Is Not To Be Removed from Head the Bearing Plate Nuts Should Not Be Removed, and the Head Should Be Forced Off by Pressure With Special Wrench at Commutator End of Shaft, as Shown in Fig. 215.

An eye in the end of this rod as shown in Fig. 211 makes it possible to insert a hand bar so as to exert a heavy twist easily. Of course, the armature and pulley are free to turn, but the rod in the pulley puller can be turned in its yoke, forcing the pulley off, by "bumping" the armature; that is, giving it a quick turn in a left hand direction until the bar strikes either the floor, car frame, or suspension, causing it to stop suddenly. The momentum of the armature will then carry the shaft forward, having very much the same effect in removing the pulley as if the armature and shaft were blocked solid, and the pulley puller rod twisted in a right hand direction.

Removing the Pulley End Housing.

After removing the pulley, loosen the six cap screws holding the pulley end housing and also the six nuts of the bearing plate. The housing can then be removed by screwing two of the cap screws into the housing at the tapped holes marked JJ, Fig. 212. There is a tendency on the part of some men to use a cold chisel in starting the housing after the cap screws have been removed, but this should not be done as it will mar the machined face of both the housing and the generator frame. This will prevent the surfaces of the housing and frame from coming together and will throw the bearing out of line, causing a hot bearing if the generator is equipped with sleeve bearings, and poor alignment in the case of a ball bearing.

In a few of the earlier types of Gould ball bearing generators put on the market, the rear, or pulley end housing was not equipped with a bearing inspection plate. On the later machines, however, a bearing inspection plate is provided so that when it is desired to simply inspect the ball bearing this can be done by removing the inspection plate without removing the housing. After the end housing or head has been removed this exposes the ball bearing and bearing plate which is to the rear of the bearing. In removing the ball bearing from the shaft a spanner wrench, in the form of a semi-circle, should be used to remove the bearing lock nut, as shown in Fig. 216. Before this nut can be started, however, the "G" ring, which locks the nut in place, must be first removed. This "G" ring is shown inserted into the bearing lock nut in the foreground of Fig. 213.

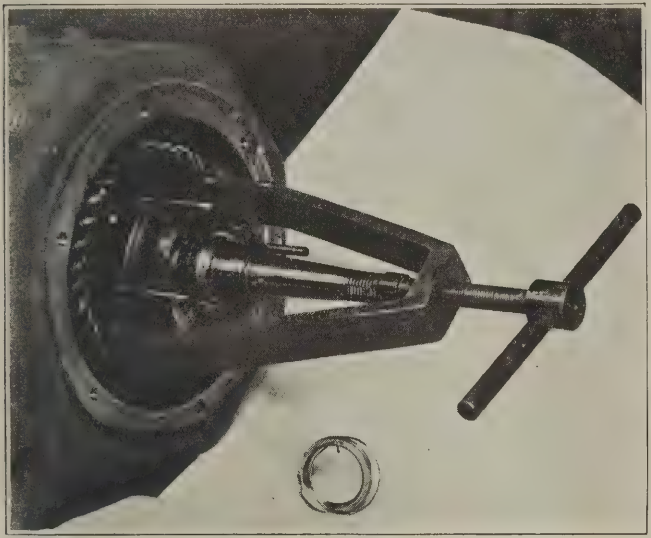


Fig. 213. The Bearing Puller in Place. Note the Square End Pressure Block. Bearing Lock Nut and "G" Ring Are Shown in the Foreground.

Removing the Pulley End Ball Bearing.

A ball bearing puller should be employed for this purpose, as shown in Fig. 213. This hooks around back of the bearing plate and the screw rod of the puller, which is provided with a brass block so as not to injure the shaft center, bears against the end of the armature shaft. After removing the bearing from its mounting it should be carefully cleaned off so as to remove all grease and dirt. One of the best ways to do this is simply to turn the steam hose on it, although kerosene may be employed if a steam hose is not available. This, however, requires that the bearing be soaked and worked considerably in order to remove all of the grease and dirt. Don't use gasolene as this will leave grit on the balls and races. If an S. K. F. ball bearing is used the bearing can be taken apart and the balls and races wiped carefully.

The outer raceway of the ball bearing is supposed to "creep" slowly in its mounting so that the balls will wear it evenly; therefore the inspector on removing the bearing should observe it carefully and note whether or not the outside face of the outer race is more or less polished, showing the effects of revolving and wearing slightly in its mounting.

Removing the Commutator End Ball Bearing.

Remove the two wing nuts holding the inspection plate over the trip carrier and unscrew the hexagonal lock nut on the end of the shaft. After giving this nut about one turn the larger nut at the rear can be driven back with a hammer and this loosens the lock nut so that it can be easily unscrewed by hand the rest of the way.

The trip carrier can then be pulled off the armature shaft; if any difficulty is experienced in removing it, there are provided two tapped holes in the face of the trip carrier for inserting two cap screws so that the trip carrier may be forced off with a bar. After the trip carrier has been removed this exposes the bearing plate covering the commutator end ball bearing. The six machine screws holding the bearing plate should then be removed. It will be found necessary to throw over the pole changing switch by hand in order to get at one of the bearing plate screws. The bearing plate can then be removed by screwing two of the cap screws into the holes provided for this purpose in the plate and these screws force the plate loose from the generator housing.

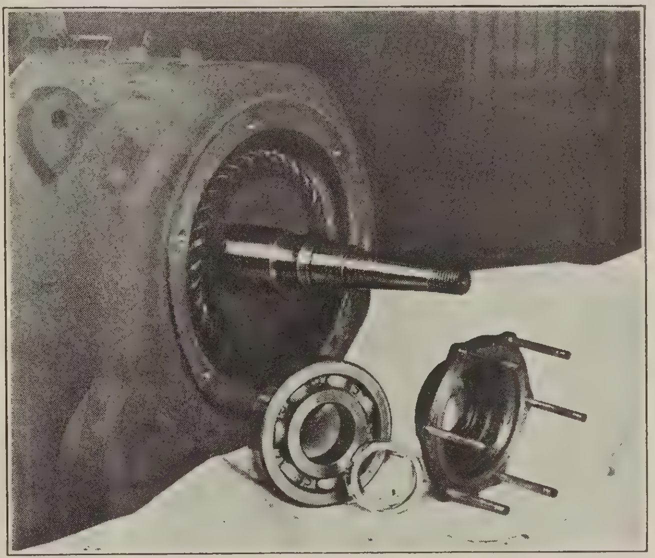


Fig. 214. The Bearing, Lock Nut and Bearing Plate After Having Been Cleaned.

The bearing plate adheres rather solidly to the housing because of the fact that a coat of shellac is given the face of the plates when they are assembled. This is for the purpose of preventing the bearing grease, which may have become thin in service from leaking into the generator housing. As the bearing plate is withdrawn, it will have to be turned until the notch in the edge of the plate comes into proper position so as to pass one of the stud bosses on the housing. Some of the earlier ball bearing equipments may not have this notch in the bearing plate, but this can easily be ground by the car lighting man overhauling that equipment.

When the plate is replaced care should be taken to see that it is put back in the same position as when taken off, that is with the notch at the bottom; this is necessary because the shellac may stick unevenly to the two surfaces, and if not put back in the same position will cause the joint to leak.

A special hollow wrench or tool threaded at one end and having a cap screw at the other end is then slipped over the shaft and screwed into the tapered bushing of the ball bearing. With this tool in place, as shown in Fig. 215, a few turns of the cap screw with a hand wrench will force the armature shaft out of the taper fit of the ball bearing sleeve. This special hollow wrench acts both as a guide for the armature shaft as it is being withdrawn or replaced, and also as a handle for removing and applying the ball bearing, as shown in Figs. 216 and 217.

In removing the ball bearing the generator shaft need only be withdrawn about 6 in. so that the bearing can be dropped down sufficient to pass the pole changer switch; the armature need not be removed entirely for this purpose. The bearing can then easily be withdrawn, the special wrench acting as a handle for holding the bearing while it is being cleaned.

It is not necessary to remove the tapered bushing from the ball bearing while it is being cleaned, but if for any reason it becomes necessary to remove this tapered bushing, this can be done by first removing the "G" ring and unscrewing the bearing lock nut with the spanner wrench, as is shown applied in Fig. 216; the bushing can then be either driven out of the bearing with a hard wood block or it may be possible to do this by striking a few upward blows on the end of the hollow wrench, but this wrench must first be screwed solidly in place so that the threads of the wrench and bushing will not be injured by doing this.

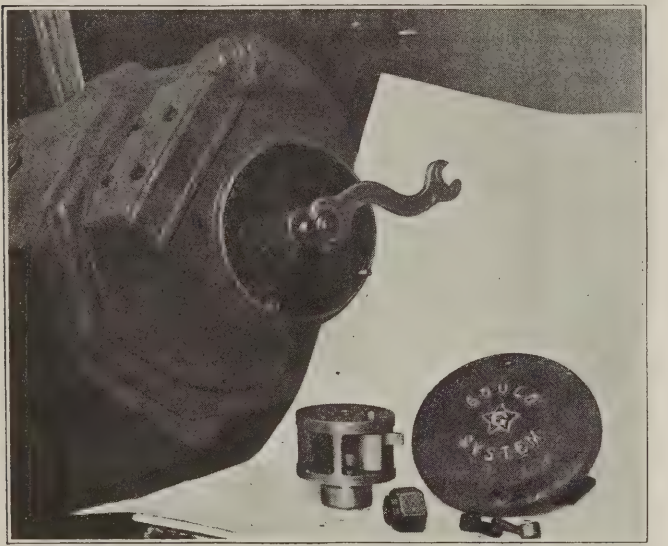


Fig. 215. Removing the Commutator End Ball Bearing. Special Hollow Wrench Slipped Over the Shaft Screws Into the Tapered Bushing of the Bearing. The Stud in the End of the Hollow Wrench Can Then Be Screwed in, Forcing the Armature Shaft Out of the Tapered Bushing of the Bearing.

Replacing Ball Bearings.

After the pulley end bearing has been thoroughly cleaned with either a steam hose or kerosene, it can be remounted on the armature shaft by using the special tool, as shown in Fig. 217. In arranging the set up for this view the bearing plate has been omitted; this, of course, must be slipped on the shaft before the ball bearing is applied. This tool used in replacing the bearing is simply a sleeve which can be slipped over the armature shaft and bears against the inner race of the ball bearing. The other end of the sleeve has a hole drilled in it which allows the threaded end of the armature shaft to project through, so that a plain nut can be screwed on, causing the sleeve to press the ball bearing into place. Some generators have the pulley held in place by a Columbia lock nut. This, of course, cannot be used in forcing the ball bearing into place with this tool because of the fact that the nut would lock as soon as it began to force the bearing.

After the ball bearing has been pressed home against the shoulder on the armature shaft the bearing lock nut should be applied. It will be noted that there is a center punch mark on one face of the lock nut, and the nut should be applied so that this punch mark comes to the outside. The lock nut should then be tightened with the spanner wrench until it is drawn up tight. In order that the lock nut may be brought so as to register directly over the corresponding hole in the shaft, it will be noted that there is a similar punch mark on the armature shaft and when the punch mark on the bearing lock nut is brought so that its punch mark and that on the shaft are right together, the hole in the lock nut will then register exactly with the hole in the shaft so that the "G" ring can readily be applied.

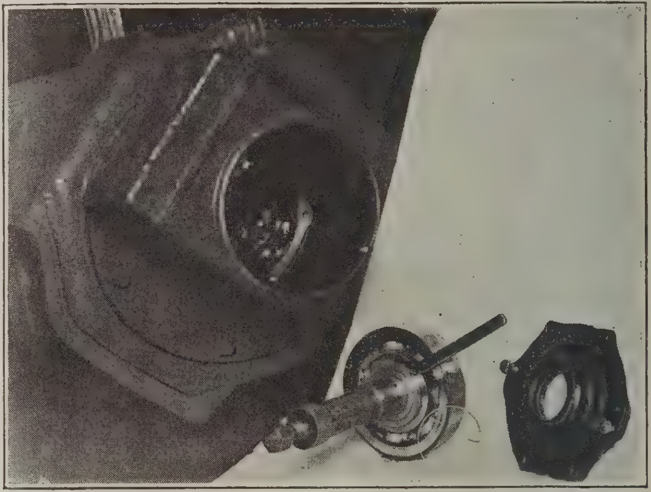


Fig. 216. Commutator End Ball Bearing Plate and Bearing Removed. Note the Special Hollow Wrench Acts as a Handle for Removing and Inserting the Bearing. A Spanner Wrench Is Shown in Place on the Bearing Lock Nut, the "G" Ring Having Been Removed as Shown.

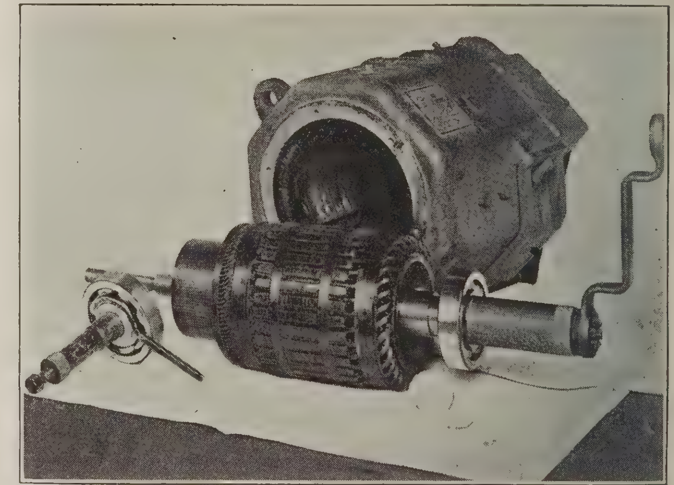


Fig. 217. Method of Applying Ball Bearing to Pulley End of Shaft. Hollow Cylinder Bears Against Inner Race So That a Plain Nut Screwed on the End of the Armature Shaft Forces the Bearing Home Solid Against the Shoulder. Note That the Ball Bearing Plate Has Been Accidentally Omitted in This Setup. This Should Be Slipped on the Shaft Before the Ball Bearing.

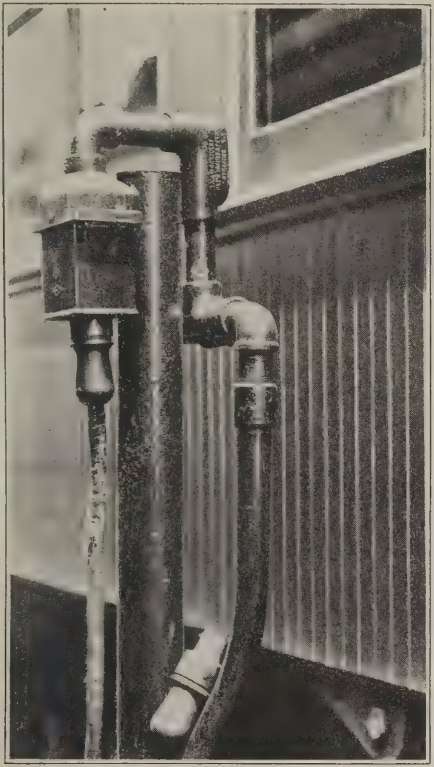
(*To be Continued*)

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

New Yard Charging Receptacle.

We have recently designed and installed a new yard charging receptacle which seems to eliminate the objections and retain the advantages of both the overhead distribution and the underground system. It is considered on our road unadvisable to have receptacles mounted low where they become stumbling blocks, so it was decided to either put the receptacles below the level of the runway, or well above it, where they could be seen by the people in the yard and at the same time would be out of the way and could not be damaged by being run over by heavy trucks, etc. Several types of receptacles and receptacle mountings have been tried out but the one shown in the accompanying illustration has been found to be the most satisfactory.



New Type of Yard Charging Crouse-Hinds Receptacle Installed at C. & W. I. R. R. Yards.

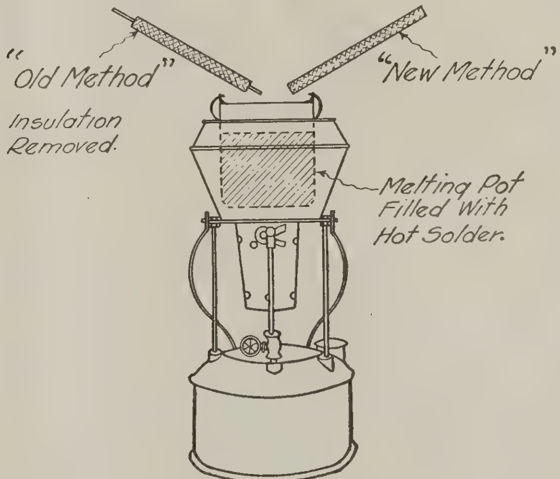
The yard charging system is what is known as the series type and the distribution line, consisting of two No. 2 wires is carried in conduit underground. A 4-in. iron pipe about 9 ft. long is driven 3 ft. in the ground and this serves as the mounting for the receptacle, as shown. The conduit is brought up out of the ground at the post, without any junction box whatever and another conduit line is passed down from the receptacle to the ground. This latter return conduit happens to be behind the 4-in. pipe in the illustration.

A "T" condulet is inserted in the conduit line near the top of the post and both of the wires of the series circuit pass through this. One of the wires, however, is cut and the two ends lead up to the "L" condulet above. Here connection is made with the wires from the receptacle.

The receptacle is of a type very similar to that used for mounting on cars, except that it is supplied with a special cap having flanges which overlap the receptacle and are equipped with a rubber bushing to make the receptacle water tight. A substantial hub at the top of the cap makes a strong and water tight connection to the conduit line above. If it is found necessary, the receptacle can be strapped to the supporting pipe, although this strap is omitted in the accompanying illustration for the joint of the nipple at the top is screwed up tight so that the iron post is bound between the receptacle and the "T" condulet.—J. L. Ohmans, Elec. Fore., C. & W. I. R. R., Chicago.

Wire Connectors for Car Lighting Batteries.

Instead of skinning the ends of the wire and then tinning it, it is advantageous to tin the ends before removing the insulation. To make a car lighting battery lead take a piece of insulated wire of the proper length and dip the ends first into the soldering flux and then into a melting pot of hot solder. Allow it to cool and remove the insulation.



This has several advantages over the old method. The heat of the solder loosens the rubber insulation from the wire and makes it easy to remove and in case of flexible wire the strands are soldered together, making it impossible to separate them while removing the insulation.

Charles W. T. Stuart, Penn R. R.

A Communication.

To the Editor:

Regarding the article published in the Railway Electrical Engineer, written by me, on "Electric Lighting of Passenger Cars," I would like to point out that this paper was prepared for the Central Railway Club, Toronto, and written so as to interest the average railroad man, and does not claim to deal with the subject from a technical standpoint.

Yours truly, E. S. M. MACNAB,
Engineer Electric Car Lighting, Can. Pac. R. R.

General News Section

Mr. H. G. Thompson Appointed General Sales Manager of the Edison Storage Battery Company.

Harrison G. Thompson, vice-president and manager of the railroad department of the Edison Storage Battery Co., has recently been appointed general sales manager, having charge of all sales, including the railway, house lighting and commercial departments. Mr. Thompson has long been active in the railroad electric car lighting and storage battery work, in fact, he is one of the pioneers in this line.

He was born in Massachusetts in 1875 and entered the employ of the Pullman Co. at the age of 21, two years later being made foreman of electricians. He subsequently held positions as battery foreman of the Riker Motor Vehicle Co., and later became associated with W. L. Bliss during the early development of the Bliss equipment. In 1905 he entered the employ of the Pennsylvania R. R. and had charge of electric car lighting at Jersey City. He later was electrical superintendent of the Safety Car Heating & Lighting Co. during the early development of their present axle lighting equipment, manager of the railway department of the Westinghouse Storage Battery, in the sales department of the U. S. Light & Heating Co., and in 1910 became associated with the Edison Storage Battery Co., with which company he has been the moving spirit in the development of their railroad sales.

Mr. R. M. Newbold Goes With Willard Battery Company.

R. M. Newbold.

The many friends of Mr. R. M. Newbold will be pleased to learn of his recent appointment as western railway sales manager of the Willard Storage Battery Co. Mr. Newbold has for many years been actively engaged in car lighting work, having been the inventor and designer of the Newbold car lighting system, manufactured by the Adams & Westlake Co., of Chicago.

Mr. Newbold was born in Pittsburgh in 1876 and after a general education entered the Rose Polytechnic Institute in 1893 and was graduated therefrom in 1897. In 1907 he received his M.S. degree and in 1908 he received his E.E. degree from this institution.

After leaving school in 1897 he went to work for the Louisville & Nashville R. R. in the mechanical department. In 1901 he went with the Louisville Ry. Co. as assistant to the superintendent of motive power on trolley and power house work. A year later he again returned to the L. & N. R. R., filling the position of electrician in charge of train lighting, shop power, etc.

While in this work he soon developed an electric axle car lighting system in which the variable field resistance was automatically cut in or out of the generator field circuit by a swinging arm carried on a pivot and on the other end of which was attached a weight with dashpots. This system has been thoroughly described in the RAILWAY ELECTRICAL ENGINEER and is known as the "Newbold" system.

In 1905 he entered the employ of the Adams & Westlake Co., of Chicago, to exploit this system of car lighting, and while with this company, developed an automobile lighting and starting system along the same lines as his car lighting system. Mr. Newbold is a Fellow of the American Institute of Electrical Engineers, and member of the following: Chicago Engineers Club, Society of Automobile Engineers, Engineering Association of the South, and Chicago Automobile Club.

Mr. Ward Barnum Leaves Louisville & Nashville Railroad.

June 15 Mr. Ward Barnum resigned his position as electrical engineer of the L. & N. R. R. to accept a position as electrical engineer with the Interstate Commerce Commisison. Mr. Barnum is a graduate in mechanical engineering of Cornell University and has had a wide experience in mechanical and electrical work since leaving school.

He has been two years with Swift & Company, one year with the Bucyrus Steam Shovel Co., of Milwaukee, two years with B. J. Arnold Co., of Chicago, one year as instructor at the Lewis Institute, Chicago; three years as superintendent of Union Light & Power Co., Covington, Ky., and for the past 11 years has been electrical engineer of the Louisville & Nashville R. R.

In his new work Mr. Barnum will be actively connected with the appraisal of railroads with particular reference to their electrical equipment. For some time in the near future he will be located at shops of the Big Four.

"Considerations in the Design of Railway Motors," a treatise on the ventilation of this type of motor by R. E. Hellmund, has just been issued in pamphlet form by the Westinghouse Electric & Mfg. Company. A large number of illustrations are used showing practice in ventilating motors together with diagrams showing the air currents through the windings and cores of the armatures.

Gould Body Hung Suspension.

The accompanying illustration, Fig. 1, shows an ingenious standard Gould car lighting generator mounted on the ordinary link type suspension, with the links shortened and modified to fit the special mounting. The suspension is mounted directly on the underframe fish belly girder of the car, cast iron blocks about 6 in. deep, being used as furring blocks. It will be noted that all of the suspension parts are identical with the standard link type suspension, except that the loops turn inward at the top instead of outward, and the pillow blocks, side irons, etc., are all mounted inside of the links instead of outside. This equipment was installed recently on the Illinois Central R. R. and seems to be giving satisfactory service. A 2½-inch trial leather belt has been used, but later standard 4-inch 4-ply rubber belt will be employed.

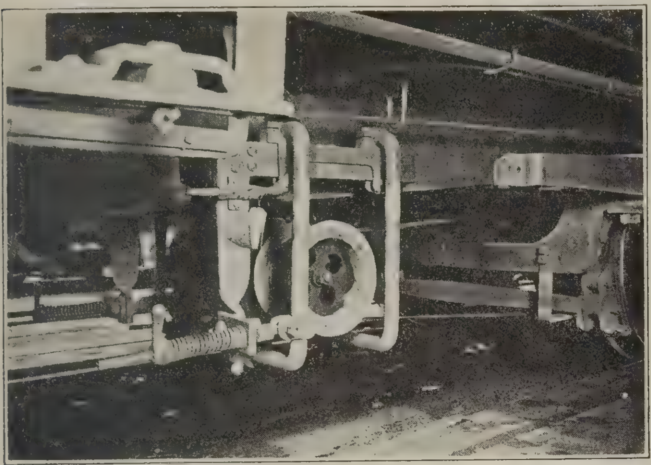


Fig. 1. Showing Body Hung Link Suspension for Gould Generator on I. C. R. R.

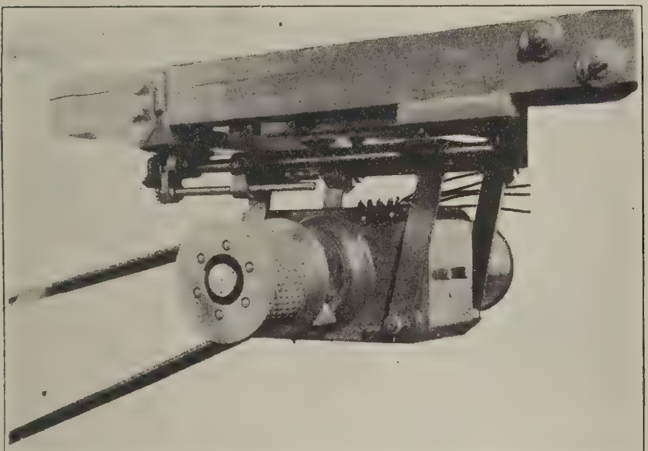


Fig. 2. Old Type Body Hung Gould Generator Installed About 1900.

It will be noted that the belt passes under the brake beam and that wide clearance is provided for the belt to clear both the brake beam and the end sill. The distance between the shaft center of the generator and the axle center is 6 ft., and this requires a belt approximately 15 ft. long. In passing around curves, the pulley center will be drawn away from, or toward, the axle, as the case may be, but the expansion or compression of the tension springs will take care of this variation without unduly straining the belt. Two-inch flared flanges have been placed on the generator pulley and the axle pulley to guide and protect the belt.

It is interesting to note the similarity of this suspension with that of one of the first Gould suspensions shown in the catalogue of that company dated 1900, and as illustrated in Fig. 2. This generator is, of course, much smaller than the present one and means are provided for shifting the top support of the links from the inside of the car, and the tension springs are omitted as this equipment is on the belt slipping principle. The general layout of the suspension, however, is practically the same as the present design.

Decisions of Recent Car Lighting Patent Suits.

Two decisions have recently been handed down in the United States Courts of interest to the railroad world.

In the suit of the Safety Car Heating and Lighting Co. vs. United States Light & Heating Co., the Circuit Court of Appeals has handed down a decision affirming the decision of Judge Hazel of the Western District of New York. Judge Hazel held that the first eight claims of the Creveling patent No. 747,686, owned by the Safety Company, which were the only claims involved in the suit, were valid, and were infringed by both the taper charge and stop charge systems involved in that suit, of the United States Light & Heating Co., the defendant. The decision of the Circuit Court of Appeals is as follows:

"We fully concur with Judge Hazel in his discussion of the questions presented and in his conclusion. The decree is affirmed with costs."

The second decision is in the case of the Safety Car Heating and Lighting Co. vs. Gould Coupler Co., in which the Safety Company was suing for infringement of the patent to H. G. Thompson, No. 1,070,080, owned by it. In this patent claims 4, 9, 10, 11, 12 and 13 were alleged to be infringed by the Simplex System of the Gould Coupler Co. in both the constant battery current and constant generator current forms. This case was tried in open court during December, 1914, and January, 1915, before Judge Hazel at Buffalo, in the United States Court for the Western District of New York. The decision holds all the claims valid and all infringed by both the constant battery current system and the constant generator current system of the Gould Coupler Company.

The U. S. Light & Heating Company advise that the stop and taper charge systems to which the decision refers, have been discontinued for some time, and that the decision does not affect the modern standard system of U. S. Light & Heating Company. The Gould Coupler Company advise that this decision affecting their equipment will be appealed immediately.

The American Pulley Company have been informally notified that they have received a gold medal for their split steel belt pulleys, a gold medal for their pressed metal, sash pulleys, and bronze medals for their reels, spools and beams.

The Standard Underground Cable Co., Pittsburgh, Pa., has been awarded a gold medal or highest award in its class, by the International Jury of Award, Panama-Pacific International Exposition for its exhibit of a complete line of electric wires, cables and cable accessories.

This is the seventh award of this degree which has been received by this company in as many different expositions and as its products have never been in similar competition oftener, this constitutes a perfect score.

The exhibit consists of samples of bare and insulated wire and cables of different kinds illustrating the great variety of these products manufactured by the Standard Company. Cable terminals, junction boxes

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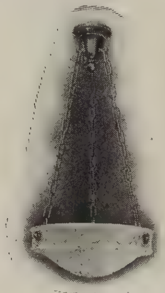

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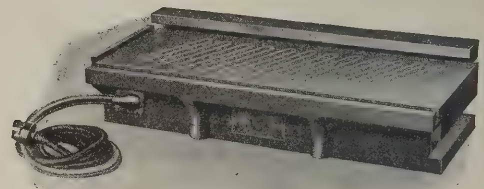

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Send for complete information.
"D. & W." Chuck Coils are wound with "Deltabeston" (asbestos covered) magnet wire, and coil units are interchangeable.

In addition to the above, we carry a complete stock in Chicago, for
dulets, linemen's tools, pole line material, glassware, reflectors, incan-
Special car material, such as car switches, distributing boxes, switch-
If it's electrical, we are in position to furnish it.

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Its features are:

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It will not dry out and lose its adhesiveness—

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It is packed in tin boxes ½ pound full weight.

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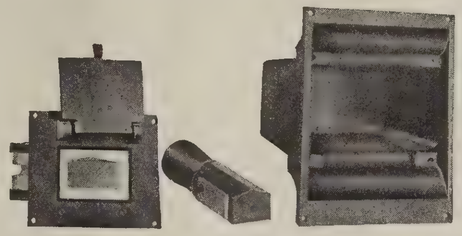

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The receptacle box is self-draining—The mounting bases are set back one inch from face of concrete, eliminating the liability to accidental breakage.

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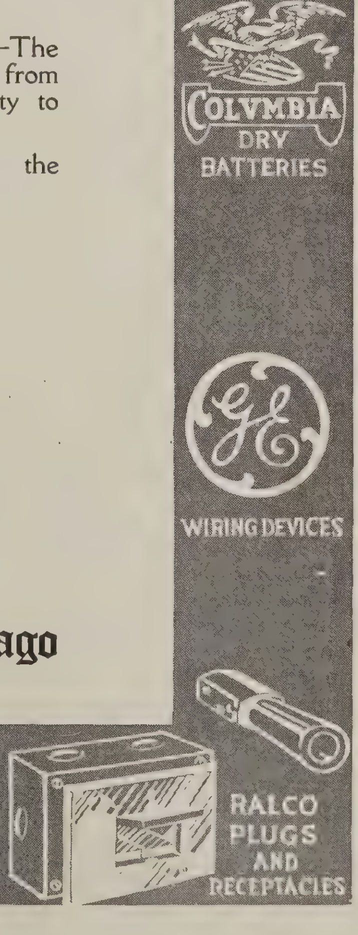
RALCO PLUGS AND RECEPTACLES

TRADE FARADAY MARK
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and other cable accessories are also shown in considerable variety adapted to various classes of service. A unique and interesting feature of this company's exhibit is the use of copper ingots as posts and a large stranded bare copper cable as railing for enclosing its exhibit space. In order to introduce some movement into its exhibit two braiding machines are shown in operation weaving cotton insulating braid on a copper wire.

The Western Electric Company was awarded the following medals by the Panama-Pacific exposition:

The Grand Prix for the exhibit as a whole. This award signifies that the products exhibited are superior to all others of their kind in the world.

Gold medals, each were awarded as follows:

One for telephone switchboards and equipment, representing apparatus standard throughout the world.

Another for telephone train dispatching and control apparatus, representing a decided advance in the art, as evidenced by the adoption of this type of equipment by many of the leading railroads of the world.

A third, for insulated wires and cables, which represent a degree of perfection in the manufacture of telephone cable that contributes largely to the present day development of the telephone system.

Two bronze medals were awarded for the company's mine rescue equipment and mine telephones.

New Electrical Railway Handbook.

The McGraw Hill Book Company have recently put a new handbook on the market for the use of operators, engineers and students, which contains practical data, formulas and tables for the solution of electric railroad problems. As the author, Mr. Albert S. Richey, professor of electrical engineering of Worcester Polytechnic Institute, remarks in the preface, "The field of the electrical railway engineer is so broad that such information has necessarily been very much scattered. . . . A great deal of valuable material has been available only in periodical publications where, unless held by a good index system, it was soon lost to the operating engineer . . . it has been the aim to present data on the subjects which come up in every day electric railway practice for constant use by the operating, constructing or designing engineer."

The scope of this volume may be judged by the titles of the sections, i. e., Road Bed and Track; Buildings; Train Movement; Railway Motors; Controlling Apparatus; Current Collecting Device; Trucks; Braking; Rolling Stock; Transmission and Distribution, and Signals and Communication. All of these sections are treated both from the point of view of the operating and constructing engineer and should prove to be of great value in both those fields.

This book contains 817 pages of printed matter bound in flexible morocco. The price is $4, of the McGraw Hill Book Co., Inc., of New York.

Railway Data Exchange.

The June issue of Westinghouse Railway Data Exchange, issued by the Westinghouse Electric & Mfg. Company, is on the subject of "Freight Hauling." This publication contains several articles among which are "Fast-Freight Service on the Winona Interurban Railway," "Effect of Brake-Setting on Power Consumption," and "Effect of Car Wheel Diameter on Motor Heating," all containing valuable information on freight haulage by electric locomotives.

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The Use of Small Rotaries in Railroad Service

Small rotary converters of special design have recently been proven to have sufficiently stable and foolproof characteristics as to warrant their extensive use in railroad service. Motor generator sets and mercury arc rectifiers have been generally used in the past for storage battery charging and in many large shop installations large motor generator sets of from 25 to 50 k. w. capacity have been installed largely for the purpose of correcting the power factor of the a. c. system and eliminating the flow of wattless current through the generator and distribution systems. Incidentally these motor generator sets furnish direct current for the operation of crane motors and motors on variable speed tools, although the advantages gained by correction of power factor alone are now considered sufficient to warrant the installation of this additional unit.

The rotary converter will operate at considerable higher efficiency than a motor generator set of the same capacity, on account of the fact that there is but one armature and one set of fields, and the machine is both a motor and a generator, so most of the losses due to armature reaction are eliminated. The peculiar characteristics of rotary converters is danger of high field voltage, liability to run away, difficulties in getting them up to synchronous speed without d. c. current, etc., requiring an experienced electrician in attendance, have been a serious handicap to the extensive use of rotary converters in small sizes.

In another part of this issue is described an installation in which a 30 k. w. rotary converter of special design is used for battery charging. This converter starts as an ordinary induction motor, not requiring any special intelligence on the part of the operator and being nearly fool-proof in its operation. With these improvements rotary converters should find a wide application in railroad service. Moreover, its constant potential characteristics make it an admirable unit for charging storage batteries by the constant potential method. This characteristic is also desirable, although not of much importance in supplying current for d. c. variable speed tool motors. A converter designed to give a strong drooping characteristic, on the other hand, will meet the special requirements of electric arc welding service, in fact, rotary converters of special design have already been used rather extensively in this class of service.

The further advantage of these machines is that they can be arranged to give a leading current and, by so doing, improve the power factor of the line on which it is operating. This is of considerable importance where induction motors are used on the same line.

Electrification and Train Delays

It is most encouraging to hear of the small number of delays in the schedules of the trains of second district of New York in the report for the year ending June 30, 1915. The figures of the public service commission are quoted as showing that out of a total of 67,080 trains, which were operated in this district in June, 93% of them arrived at their destination on time—that is not more than five minutes behind schedule. In this second district there are several electrified railroad divisions and all of these made an admirable record for promptness. Of these, the road having the least number of delays was the New York, Westchester and Boston R. R. In twelve months, out of 74,551 trains, 99.2% of them arrived on time so it cannot be said that it is a freak record for a period of fortunate operation, but is the average performance over the period of a year. Of the 625 trains that arrived late the average number of minutes lost per train was only 0.093. In the analysis of the causes for these delays, the significant fact is that in more than 77% of the cases the delays were due to waiting for other trains, a condition for which the railroad is not responsible and over which it has no control. Of the total delays, only about one and one-half per cent were due to the equipment. This has been due in a large measure to the careful inspection that the electrical equipment on this road undergoes at regular intervals; it speaks well for the ruggedness of the modern electric locomotive.

The records of the other electrified divisions in this district, the Hudson and Harlem divisions of the New York Central and the New York, New Haven and Hartford, were well above the average.

Penn. R. R. Baggage Car Lighting Tests

It will be recalled that in 1912 an extensive series of tests was made on the illumination of postal cars by the illumination committee of the A. R. E. E. and similarly comprehensive series of tests on the illumination of coaches was made the following year under the auspices of the same committee. The first series of tests on postal car lighting were reported in the March, 1913, issue of the RAILWAY ELECTRICAL ENGINEER and the second series of tests on coach lighting were reported in the October, 1913, issue of the RAILWAY ELECTRICAL ENGINEER, and were later published in book form by the association.

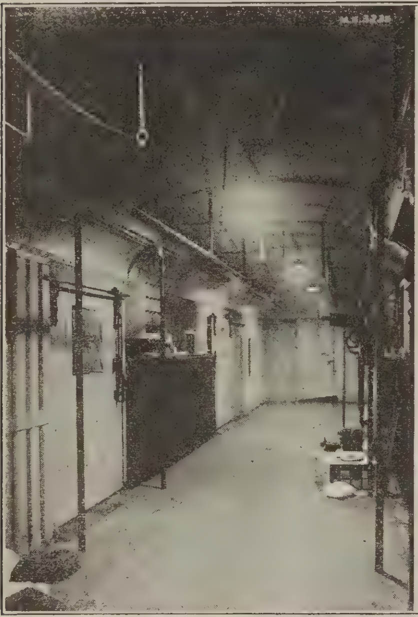


Fig. 1. Present Spacing Using BAD-60 Holophane Reflectors. Note the Heavy Shadow Lines Between the Units on the Upper Walls.

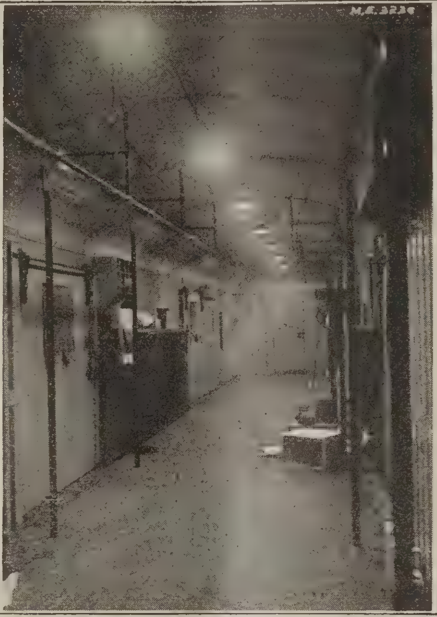


Fig. 2. Showing Illumination with 7 ft. 6 in. Spacing Recommended for PB-70 Cars. Note the Great Improvement in Shadow Lines Over Fig. 1.

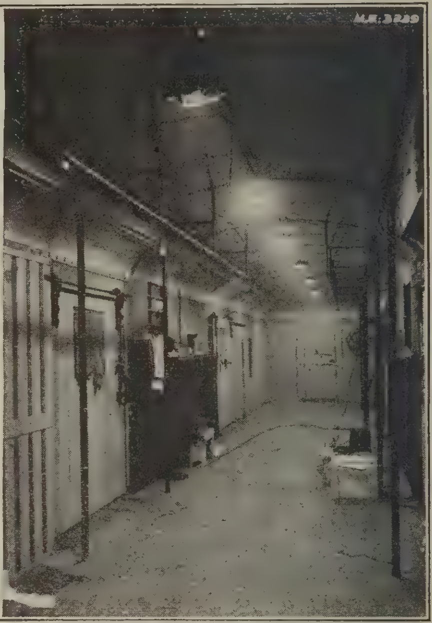


Fig. 3. Showing the Illumination with 8 ft. 6 in. Spacing which Is Recommended for B-60 Cars. Note the Shadow Lines Are but Slightly More Pronounced than in Fig. 2.

No tests were made at that time on baggage car illumination, and as this class of service involves special requirements peculiar to this service, this series of tests made by the car lighting department of the Pennsylvania R. R. will be very interesting, and may be considered as equally valuable as the previous tests of postal car and day coach lighting. Extreme care was employed to insure that all data be of high accuracy, as was done in the first tests, and some of the same men employed in the earlier testing crew were employed as operators in these tests.

The requirements for baggage car lighting are different from that of any other class of car lighting service. Baggage is piled high along both side walls, leaving a narrow aisle down the center, and illumination is desired on the tags and faces of the trunks piled both near the floor and near the ceiling of the car. Therefore, a deep bowl reflector, which would be suitable for postal car service, is not suitable for baggage car service, on account of the high screening angle of the reflector darkening the upper portion of the pile of trunks. On the other hand, a properly designed reflector of the shallower bowl type does not interfere with the illumination at the upper zone, but intensifies the illumination on trunks nearer to the floor of the car than would be obtained where bare lamps are used.

Report of the Tests

The following is the complete report of the baggage car lighting tests made by the Pennsylvania Railroad.

Object of Tests.

It was desired to ascertain whether or not sufficient illumination was being provided in baggage cars and if not, to determine an arrangement that would prove satisfactory. To form a basis for conclusions illumination tests were made in a B-60 and the baggage portion of a PB-70 car with the present arrangement of light units equipped respectively with no reflectors, Holophane aluminized steel reflector No. 18460 and Holophane aluminized steel reflector No. BAD-60, followed by tests in a B-60 car having light units at various spacings and with the different reflector equipment above mentioned.

Conclusions.

From the details of the tests hereinafter presented, the following conclusions are drawn:

1. The present arrangement of light units in PB-70 (passenger—baggage, 70 ft.) and B-60 (baggage, 60 ft.), cars with the reflector equipment now used (Holophane 18460) gives very poor illumination both in intensity and distribution, and this deep bowl type of reflector is not suited to baggage car lighting.
2. An installation of 5 units spaced 7 ft. 6 in. and equipped with Holophane reflector No. BAD-60 at

1⅜″ position is recommended for PB-70 cars and 7 units spaced 8 ft. 6 in. and equipped with Holophane reflector No. BAD-60 at 1⅜″ position for B-60 cars.

3. If, on account of the expense, it is thought inadvisable to change locations of light units in PB-70 and B-60 cars already built, it is recommended that no reflectors be used in these cars, the bare lamps giving better results than a shallow bowl reflector.

Illumination Requirements.

The load in a baggage car, when the latter is well filled, will extend from about 1½ ft. beyond longitudinal center line of car to side of car and as high as about 6 or 7 ft. along the side.

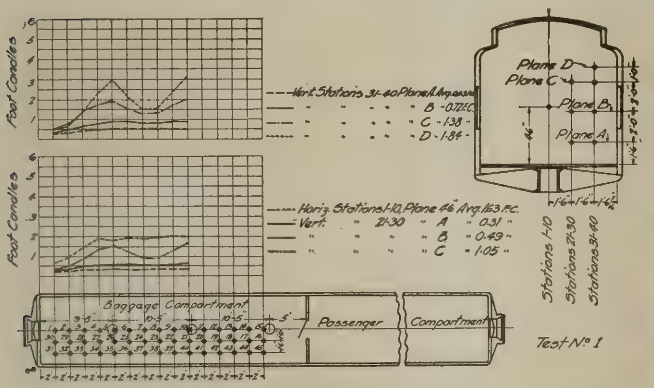
Tags and labels will ordinarily be in a vertical longitudinal plane, hence vertical and not horizontal illumination intensities are important. With any reflector equipment suitable for these requirements, the vertical illumination near floor of car and 1½ ft. from center line will necessarily be low, even though the horizontal intensity is 3 or 4 foot candles, because of the small angle between such location and the nadir of the nearest unit.

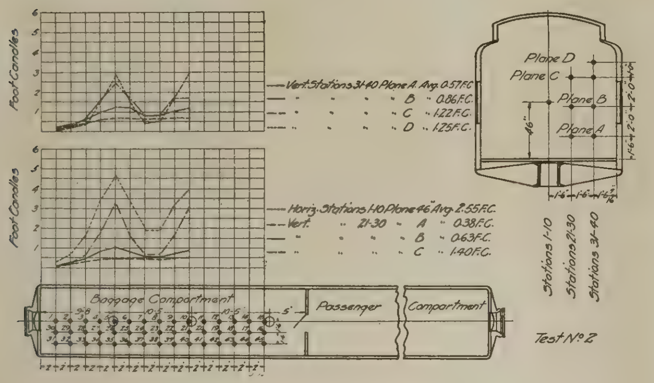
Details of Tests

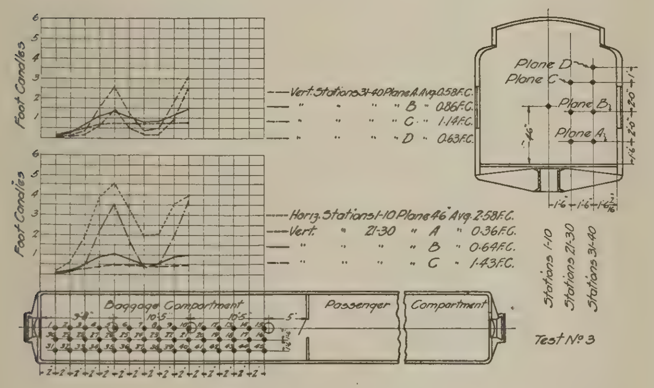
General.

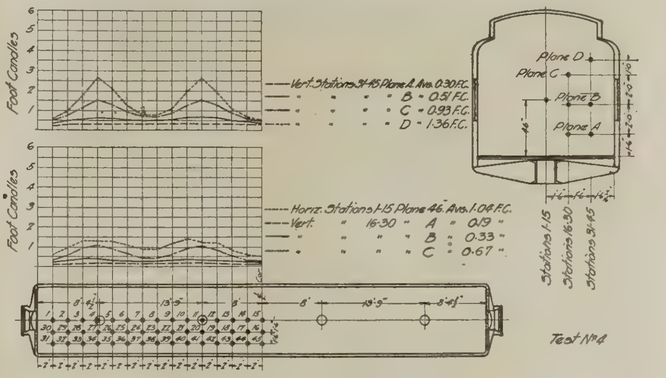
The tests were made at Altoona Car Shops in PB-70 car No. 4829 after same had been turned out of Paint Shop and in B-60 car No. 5691 which was taken out of service for the purpose, but the interior paint of which was clean. A Sharp-Millar photometer was used to obtain the foot-candle intensities and all precautions possible were taken to insure accuracy. At all stations the light measured fell directly on test plate of photometer tube, no diffusing plate for indirect readings having been used.

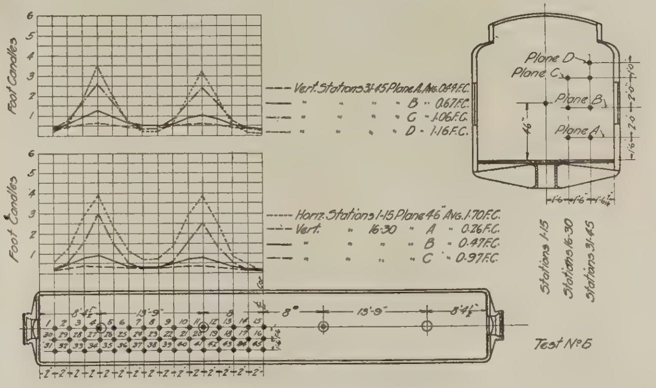
The lamps used in the fixtures were specially made without "getter" properly aged and selected to give

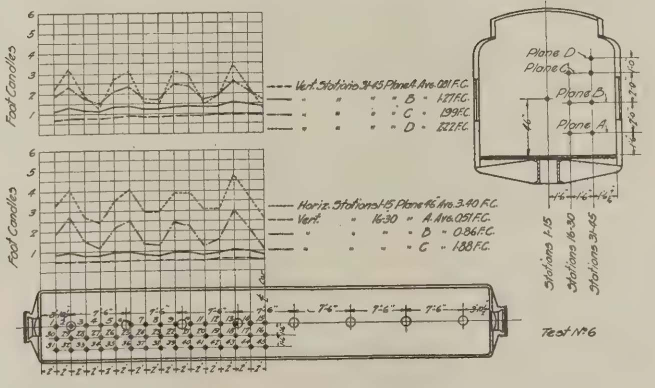












practically equal lumens, of the rating 50 watts, 63 volts, G-30 bulb, and were held at a voltage to give 37.6 H.C.P.

Equipment Tested.

Tests were made in both cars with bare lamps, and with Holophane aluminized steel reflectors No. 18460 (deep bowl) and No. BAD-60 (shallow bowl). In addition to the original spacings of lamp units, tests were made with spacings of 7 ft. 6 in. and 8 ft. 6 in. respectively. The distance between floor and center of lamp filament was in all tests of each car the same, viz: 8 ft. 6 in. in PB-70 car and 8 ft. 8¼ in. in B-60 car, the latter being obtained by using the shortest fixture of standard design.

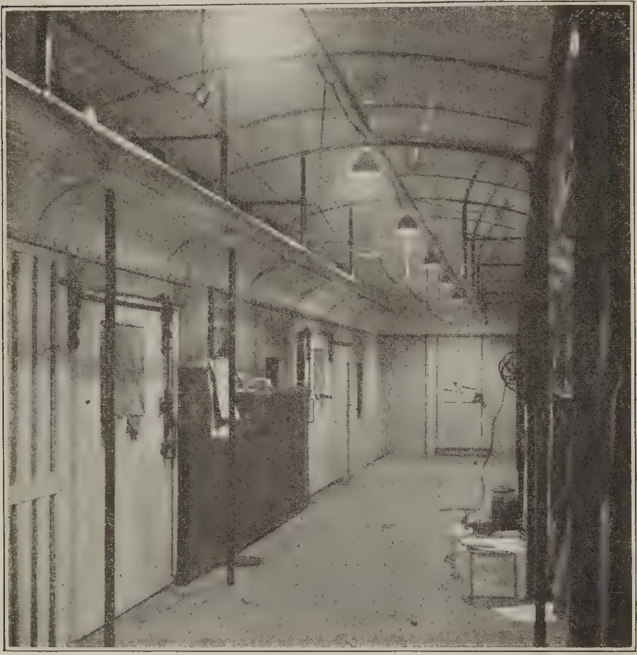


Fig. 4. Showing the Illumination with Deep Bowl Reflectors. Holophane No. 18460. Notice that Rather Heavy Shadows Are Cast on the Side Walls and Upper Ceiling Due to the Screening Angle of the Reflector.

Readings Taken.

The location of reading stations is shown on sheets No. 1 and 4 for PB-70 and B-60 cars respectively. Horizontal foot-candles were read on the center line of car on a plane 46 in. above floor, the remaining readings being in vertical foot-candles.

Averages obtained at each station are plotted on curve sheets Nos. 1 to 11 inclusive, which are self explantory. Sheet No. 12 is a tabulation of average maximum and minimum foot candle values along the same longitudinal line of car and in the same plane, as indicated.

Photographs of the interior of car with various equipment and spacings are shown in Figs. No. 1 to 4 inclusive. These are intended to show only shadow lines and are not comparable with each other to show relative brilliancy.

Analysis of Results

The present arrangement of light units in the PB-70 cars, as shown on test No. 1, brings the minimum illumination in the vicinity of Stations No. 30 and 31, and this end of the car should therefore receive prime consideration. By inspecting tests No. 1, 2 and 3 it is seen that with reflector 18460 (Sheet No. 3) the intensity is very low in the end of the car (Stations 30 and 31) and midway between units (Stations 23 and 38). Reflector BAD-60 (Sheet No. 2) slightly improves conditions around the latter named stations but does not improve the low readings at end of car. The best results are obtained by using no reflector at all as in Sheet No. 1.

Illumination Tests in Baggage Cars

Average Foot Candle Values Along Longitudinal Lines of Car

	Nature of Val.	Horiz.	VERTICAL						
		46″ Pl.	16-30A	31-45A	16-30B	31-45B	16-30C	31-45C	31-45D
Test No. 1; PB-70	Avg.	1.63	0.31	0.45	0.49	0.72	1.05	1.38	1.84
Bare Lamps	Max.	1.95	0.36	0.53	0.59	0.88	1.61	2.01	3.16
Present Spacing	Min.	0.61	0.20	0.26	0.25	0.32	0.34	0.43	0.46
Test No. 2; PB-70	Avg.	2.55	0.38	0.57	0.63	0.86	1.40	1.22	1.25
Holophane BAD-60	Max.	4.73	0.50	0.72	1.07	1.28	3.32	2.53	3.17
Present Spacing	Min.	0.32	0.14	0.18	0.13	0.19	0.09	0.10	0.06
Test No. 3; PB-70	Avg.	2.58	0.36	0.58	0.64	0.86	1.43	1.14	0.63
Holophane 18460	Max.	3.92	0.48	0.74	1.02	1.43	3.63	3.07	2.44
Present Spacing	Min.	0.15	0.11	0.15	0.08	0.10	0.05	0.05	0.04
Test No. 4; B-60	Avg.	1.04	0.19	0.30	0.33	0.51	0.67	0.93	1.36
Bare Lamps	Max.	1.43	0.21	0.33	0.40	0.62	1.12	1.51	2.62
Present Spacing	Min.	0.53	0.16	0.21	0.23	0.34	0.29	0.45	0.53
Test No. 5; B-60	Avg.	1.70	0.26	0.44	0.47	0.67	0.97	1.06	1.16
Holophane BAD-60	Max.	3.84	0.37	0.62	0.91	1.23	3.00	2.57	3.47
Present Spacing	Min.	0.35	0.14	0.26	0.18	0.29	0.11	0.17	0.09
Test No. 11; B-60	Avg.	1.93	0.29	0.51	0.52	0.80	1.22	1.06	0.68
Holophane 18460	Max.	3.86	0.39	0.74	0.99	1.62	4.27	3.22	2.80
Present Spacing	Min.	0.22	0.14	0.27	0.12	0.19	0.05	0.07	0.05
Test No. 10; B-60	Avg.	3.07	0.85	1.20	0.45	0.71	1.74	1.79	1.97
Holophane BAD-60	Max.	4.27	1.03	1.47	0.51	0.77	2.90	2.68	3.56
8′-6″ Spacing	Min.	1.82	0.66	0.97	0.39	0.58	0.73	1.07	0.70
Test No. 9; B-60	Avg.	3.12	0.46	0.80	0.82	1.23	1.96	1.66	1.06
Holophane 18460	Max.	3.93	0.50	0.84	0.97	1.47	3.64	3.12	1.94
8′-6″ Spacing	Min.	2.07	0.42	0.65	0.74	0.93	0.42	0.44	0.20
Test No. 7; B-60	Avg.	1.99	0.39	0.59	0.62	1.02	1.27	1.86	2.71
Bare Lamps	Max.	2.20	0.43	0.64	0.65	1.27	1.38	2.07	3.24
7′-6″ Spacing	Min.	1.60	0.32	0.44	0.51	0.77	1.12	1.53	2.26
Test No. 6; B-60	Avg.	3.40	0.51	0.81	0.86	1.27	1.88	1.99	2.22
Holophane BAD-60	Max.	4.70	0.59	0.93	1.04	1.54	3.00	2.59	3.33
7′-6″ Spacing	Min.	2.41	0.43	0.66	0.74	1.09	1.14	1.50	1.19
Test No. 8; B-60	Avg.	3.67	0.53	0.93	0.99	1.54	2.42	1.99	1.24
Holophane 18460	Max.	4.37	0.59	1.00	1.09	1.77	4.13	3.00	2.55
7′-6″ Spacing	Min.	3.11	0.42	0.69	0.87	1.22	0.98	0.92	0.31

Therefore, if this location of units is maintained in cars already constructed, it is advisable to remove reflectors. If practicable to change fixture locations, the results of the tests on B-60 car will apply equally to PB-70 in determining best spacing.

Present Spacing.

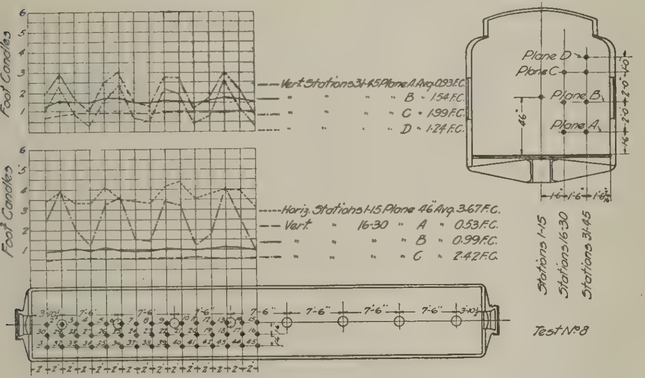
60-Foot Baggage Cars.

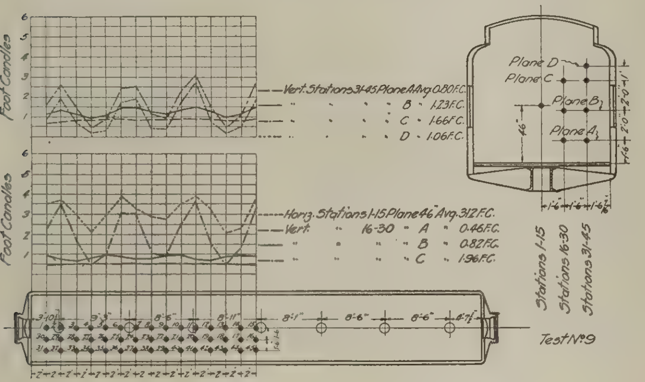
Tests made	Sheet No. Plots	Sheet No. Photographs
Bare lamps	4	..
BAD-60 reflector	5	13
18460 reflector	6	14

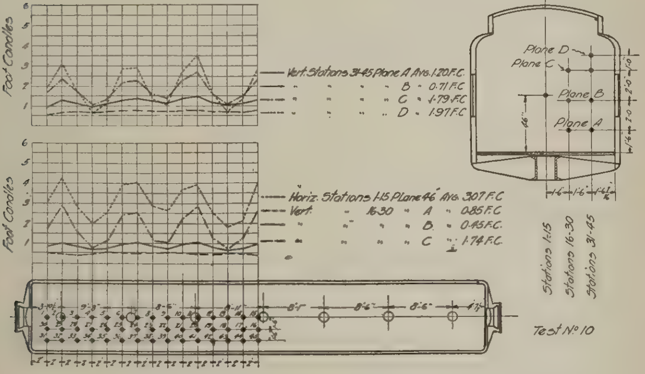
By referring to tests No. 4, 5 and 11, it is seen that, with present spacing of light units, the intensity values fall so low at a considerable number of points as to make these minimum values the determining factor in selecting equipment. Table No. 1 shows the minimum values to be as follows:

Stations	Bare Lamps	BAD-60	18460
Horizontal	0.53	0.35	0.22
16-30 A	0.16	0.14	0.14
31-45 A	0.21	0.26	0.27
16-30 B	0.23	0.18	0.12
31-45 B	0.34	0.29	0.19
16-30 C	0.29	0.11	0.05
31-45 C	0.45	0.17	0.07
31-45 D	0.53	0.09	0.05

On all reading planes, except stations 31 to 45, plane A, the bare lamps show better results and the rank of equipment is: 1st, bare lamps; 2nd, BAD-60; 3rd, 18460.







If it is inadvisable to change the spacing in B-60 cars already built, it is recommended that no reflectors be used.

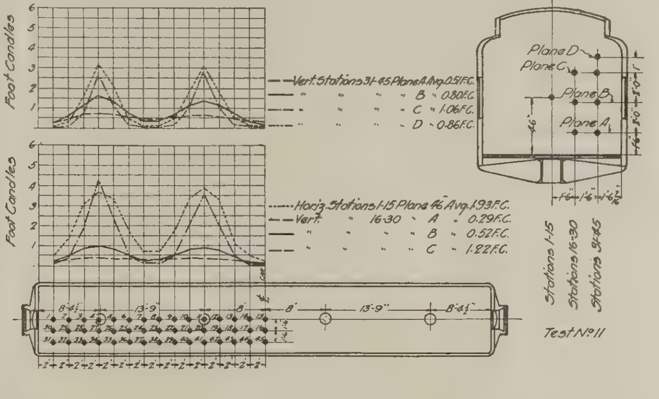
8 Ft. 6 In. Spacing.

Tests made	Sheet No. Plots	Sheet No. Photographs
BAD-60	7	15
18460	8	16

Tests 9 and 10 show the illumination resulting from an 8 ft. 6 in. spacing of light units to be considerably lower midway between units with 18460 than with BAD-60 reflector, on the two upper planes C and D. In other words, 18460 reflector cuts off the light in such a manner that there is a dense shadow cast on the side of car which shadow is longest midway between units as may be seen by referring to the photograph, Fig. 4. This shadow is much shortened and less dense with BAD-60 reflector, as shown in photograph, Fig. 3.

The BAD-60 equipment at this spacing gives ample illumination throughout the car with sufficient uniformity and is therefore recommended for B-60 cars.

If this spacing is used in PB-70 cars, the distance between the ends of car and first unit would be 5 ft., which is too great to give sufficient illumination in ends of car. It is therefore recommended that 5 units equipped with BAD-60 reflectors be used in PB-70 at a spacing of 7 ft. 6 in.



7 Ft. 6 In. Spacing.

Tests made	Sheet No. Plots	Sheet No. Photographs
Bare lamps	9	..
BAD-60	10	17
18460	11	18

The results of the tests at a 7 ft. 6 in. spacing show, with all equipment, slightly more uniformity and somewhat higher intensities on certain stations than with the 8 ft. 6 in. spacing but hardly enough better in these respects to warrant the extra unit, considering the desirability of keeping the total wattage as low as possible consistent with sufficiently good results.

Test No. 8 shows the foot-candle plots by use of 18460 at this spacing and shows that, even at so close a spacing, the 18460 has too low an angular cut-off to meet the requirements, the illumination on plane D falling too low between units. Altoona, Pa., May 1, 1915.

Train Dispatching by Wireless.

It is now possible to communicate from a moving train to a fixed station a distance of 130 miles. The train radio service has been used for a variety of purposes, such as reporting the number of passengers on board for connecting lines, for ambulance service and commercial telegrams. The cost is not prohibitory considering the advantages to be gained. One year the pole lines in New Jersey and New York and Pennsylvania were almost completely wrecked by sleet storms, and wireless was about the only communication for about 10 days.

Axle Generator Equipment for Head-End Train Lighting

The head-end axle generator system for electric train lighting, although of very recent practical development in this country, is by no means new, for one of the first trains to be equipped with electric light in England in 1881 employed a system for lighting their cars in which the dynamo, mounted in the baggage van, was belt driven from the car axle. The difficulties of satisfactory mounting of the generator, drive and automatic generator control in capacities sufficient to handle the lighting load of a modern Transcontinental American train, however, were found to be so great that head-end train lighting in this country has up to recently employed a steam driven turbo generator as source of power.

The Northern Pacific R. R. and the Gould Coupler Co., however, have been very active during the past six years in the development of a head-end axle generator system which will measure up to the requirements of present day American electric train lighting. The first experimental equipments installed on this road were described in the RAILWAY ELECTRICAL ENGINEER of October, 1914, and it will be noted from comparing this article with the earlier description, that marked improvements have been made, both in the general principles and detail design of the equipment.

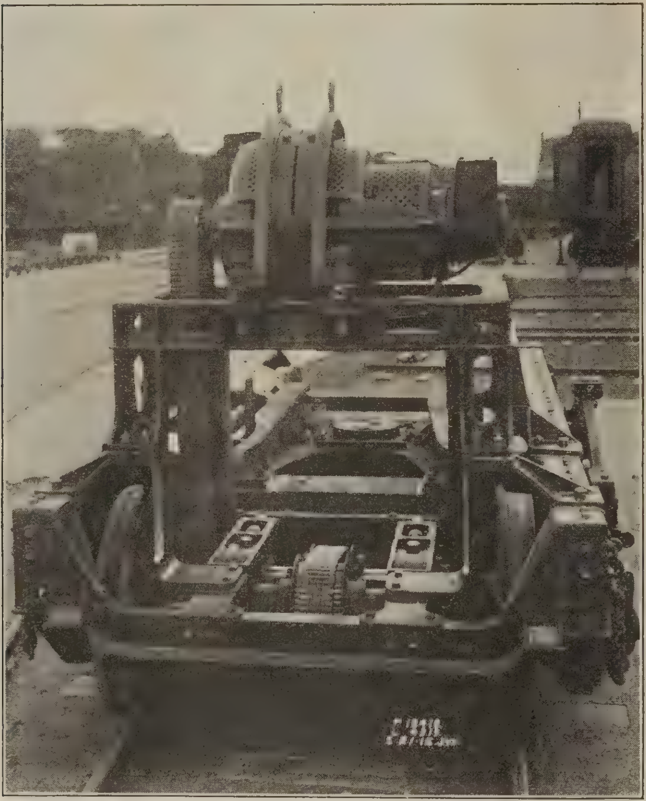


Fig. 1. End View of the Truck Showing Axle Gear and Chain Driving Jack Shaft, Also Vertical Chain Connecting Jack Shaft to Generator.

The first experimental equipment was installed in 1909, and in 1912—3 trains, running between St. Paul and Winnipeg, were each equipped with a 4 k.w., 50 ampere, 80-volt safety axle generator outfit. In 1913, 7 trains were equipped with a 4 k.w. Gould Simplex axle generator equipment, each of which lighted a train of 4 cars. The 4 k.w. equipments are still giving complete satisfaction.

In 1914, one train was equipped with a 20 k.w. head-end axle generator system, and in June, 1915, 2 additional equipments of 17½ k.w. capacity were installed, making in all at the present time 10 short trains with 4 k.w. equipment and 3 through trains equipped with 17½ k.w. or 20 k.w. equipment.

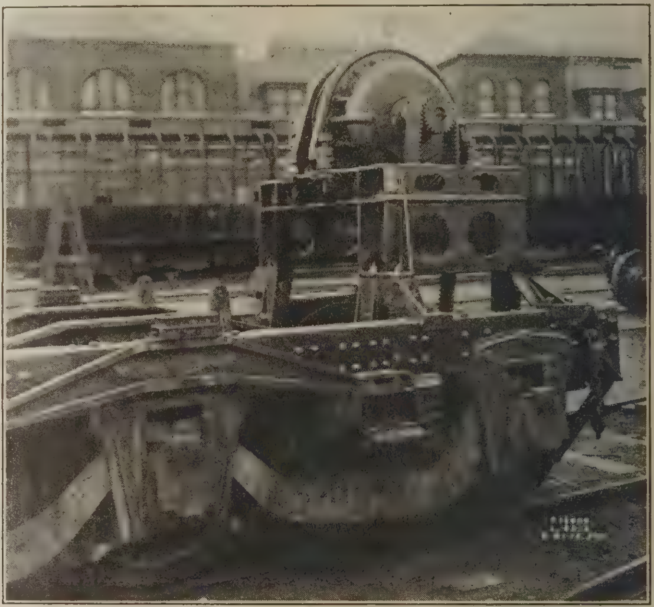


Fig. 2. Side View of Truck Showing Generator Mounted Over the Forward End of the Forward Truck so as to Come at the Extreme Forward End of the Car.

Generator.

The generators on the latest equipments installed have a capacity of 17½ and 20 k.w. at 80 volts. They are constructed as six pole compound wound machines, having interpoles to insure proper commutation and operate at 300 to 2,100 r.p.m. The generator is mounted on a cast steel base which spans between the forward end sill and the center sill of the truck, as shown in Fig. 1. On top of this frame work is mounted a four-legged, cast-steel pedestal support which projects through the floor of the baggage car, as shown in Figs. 2 and 6 and on top of this pedestal the generator is rigidly mounted. A steel casing built in hinged sections completely covers the generator so as to protect it from injury by baggage, etc., and a flexible canvas gasket fitted across the opening between the generator pedestal and car floor excludes all cold weather, dust and water from the roadbed.

The generator is mounted on ball bearings, which eliminate many bearing and commutator troubles due to oil splashing, etc.; these ball bearings require very little attention, being inspected only once in three months. The generator rides surprisingly well and far better than one would expect with a machine mounted directly on the truck and it runs very quietly, even under severe conditions of load and high speed.

The Chain Drive.

The generator is driven by a 5-inch .9-inch pitch Morse silent chain operating from a jack shaft located directly below the generator pinion and mounted on the supporting frame of the generator. The jack shaft in turn is driven from the axle by means of a horizontal chain connecting the jack shaft pinion with a large sprocket mounted on the forward car axle. The horizontal chain between the axle and the jack shaft was at first completely encased in an oil tight galvanized iron case, permitting it to run in a bath of heavy oil and graphite. Subsequent experiments with this casing removed, however, has shown that this is not at all necessary and that when both chains are occasionally lubricated with a heavy grease, consisting of a mixture of Kent's compound and flake graphite, half and half, the chain drive is found to give very satisfactory operation.

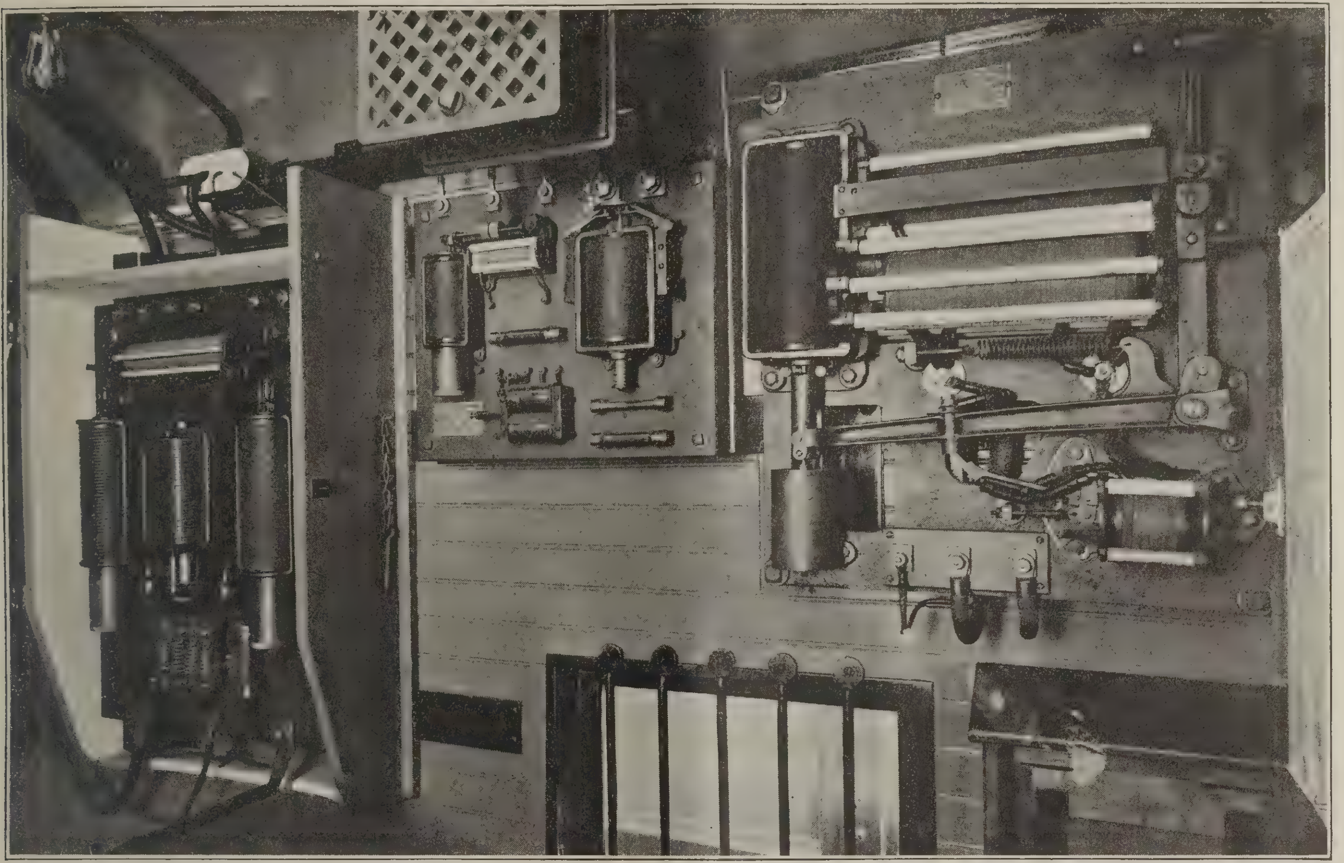


Fig. 3. View of Regulating Panel Boards. At the Left Is the Generator Regulator with Voltage and Current Solenoids, Automatic Switch in the Center and Below This, Four Shunt Resistance Coils in Parallel with the Current Regulating Solenoid. The Center Panel Carries the Lamp Voltage Multiplier, and the Relay for Inserting Resistance Bank In Is Mounted Above. The Right Hand Panel Is Mounted, the Lamp Regulator Having Three Large Carbon Piles. Pressure Plate Is in the Form of an Equilateral Triangle with Compressing Force Applied at the Center; at the Left End of the Piles Is an Equalizing Bar, Also in Triangular Form which Equalizes the Pressure on all Three Piles.

One pair of chains used for driving the first 20 k. w. generator gave a mileage of 140,000 before they were removed. During this time the short horizontal chain did not stretch appreciably and no slack was taken up, but in the long vertical chain it was found necessary to take up 2 inches after the first 20,000 miles operation. These chains were removed when the sprockets had reached the limit of their wear after 140,000 miles operation, and have been sent to the manufacturer to be re-pinned. They advise that the re-pinned chains will be practically equal to new chains.

Generator Regulator.

The regulator of the generator is of the same design as the standard Gould "Simplex" system, except that it is built larger and more substantially in all parts, as will be noted from the photograph, Figs. 3 and 6. The large solenoid on the left being the series solenoid, has a capacity of 250 amperes and this can be set so as to provide any desired current output as follows: 100, 125, 150, 175, 200 amperes and this solenoid will control the generator output at this current value at all speeds.

The generator voltage regulator solenoid mounted on the right side of the generator regulator panel controls the generator voltage between the limits of 78 and 83 volts, depending upon the temperature of the regulating coil. As in the standard Gould Simplex system, as the batteries of the train are brought up near a full state of charge their voltage will rise and the generator voltage, rising correspondingly, will reach this maximum setting. As the charge continues further the voltage will be held at this point by the voltage regulator and accordingly the current to the batteries will gradually taper off to a low value so that the batteries will not be seriously overcharged.

The 4 coils of wire shown in the left panel of Fig. 3, mounted directly below the automatic switch, are segments of a low resistance shunting the winding of the current regulating coil by means of which the current setting of the regulator can be adjusted to the values of 125, 150, 175 and 200 amperes as desired.

Automatic Switch.

The automatic switch is of the same general design as the standard Gould switch but is built much heavier in order to handle the large capacity of the machine. This is shown mounted in the center of the regulator panel. The switch on these particular equipments is adjusted to close at 66 volts cold, and 68 volts hot, and will drop out when there is a reverse current of 10 amperes from the batteries through the generator.

Train Line Connections.

As is well known, head-end train lighting systems in the past have generally employed a single circuit three wire system, having both batteries and lamps connected between the positive train line and the negative return loop. In this axle generator head-end system, however, the three train lines are divided into two separate two wire circuits having a common return. In other words, the lamps are connected between train lines 1 and 3, Figs. 4 and 5, and the batteries of the train are connected between train lines 1 and 2.

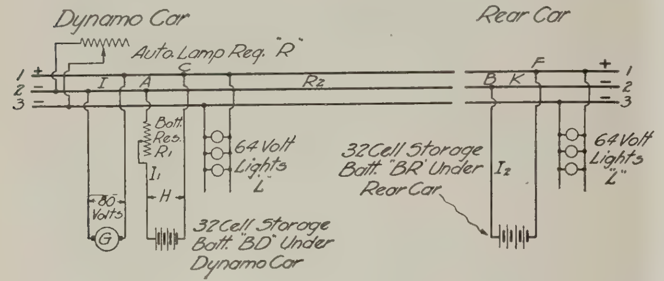


Fig. 4. Simplified Wiring Diagram Showing Train Line Connections and Method of Equalizing the Charge and Discharge Voltages of the Batteries at Both Ends of the Train. The Resistance R′, Inserted in the Circuit of the Forward Battery, Reduces the Voltage of the Forward Battery Both on Charge and Discharge, Compensating for the Voltage Drop Line in the Train Line Circuit to the Rear Battery.

The voltage of the current delivered to both the batteries and the lamps can then be automatically adjusted to proper value by means of the controlling apparatus in the baggage car, the batteries receiving full charging voltage while the lamp voltage is maintained constant by means of the lamp regulator.

The Lamp Regulator.

This lamp regulator is constructed on the same general principles of design as the standard Gould "Simplex" lamp regulator, but in order to take care of a maximum lamp current of 125 amperes, and with this current flow to absorb the difference between maximum generator voltage of 83 and normal lamp voltage of 66, representing a heat absorbing capacity of approximately 2 k.w. under the most severe conditions, has required that the regulator be constructed on much larger design. An auxiliary bank of resistance grids is also employed, which is automatically switched in at the higher voltages.

The lamp regulator proper is equipped with a multiplier which intensifies the action of the regulator and makes it very sensitive to slight changes in voltage in a manner very similar in operation to the Gould Simplex lamp regulator, which will be described in next issue. It will be noted from Fig. 3, however, that the carbon piles of the lamp regulator are of large proportions and that there are three carbon piles which are connected in parallel instead of two piles being connected in series, as is the case with the standard single car equipment.

The large view of the regulator panel boards, Fig. 3, shows the current and voltage coils of the generator regulator and automatic switch at the left, encased in a protecting box; the center panel carries the lamp regulator multiplier relay with solenoid for switching in the bank of resistance, shown at the top of the illustration, when the lamp voltage rises above 74 volts; and at the right is mounted the large lamp regulator proper.

It will be noted that this lamp regulator has a short

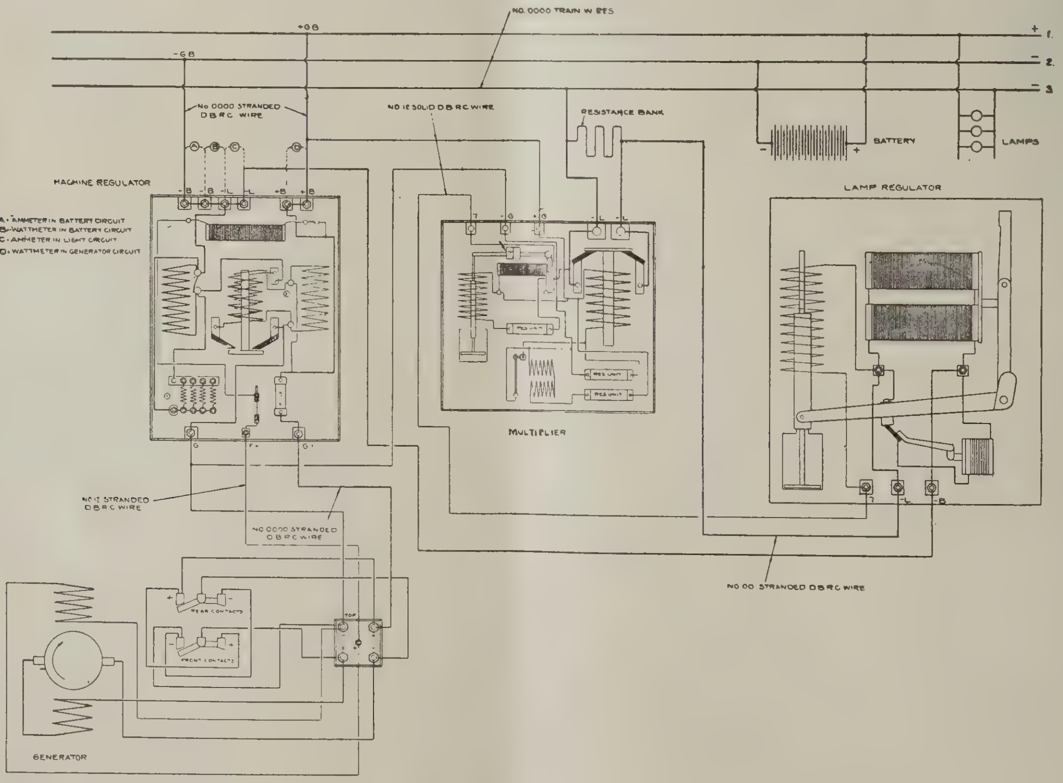

NO. 0000 TRAIN WIRES
+GB
−GB
+ 1
− 2
− 3
No 0000 STRANDED D B R C WIRE
NO 12 SOLID D B R C WIRE
RESISTANCE BANK
BATTERY
LAMPS
MACHINE REGULATOR
A · AMMETER IN BATTERY CIRCUIT
B · WATTMETER IN BATTERY CIRCUIT
C · AMMETER IN LIGHT CIRCUIT
D · WATTMETER IN GENERATOR CIRCUIT
−B
−B
−L
−L
+B
+B
7
−G
+G
−L
−L
LAMP REGULATOR
MULTIPLIER
G
F
G
7
−L
−B
NO 12 STRANDED D B R C WIRE
NO 0000 STRANDED D B R C WIRE
NO 00 STRANDED D B R C WIRE
REAR CONTACTS
FRONT CONTACTS
TOP
GENERATOR

Fig. 5. Complete Wiring Diagram of Regulator Panels. This Is Very Much the Same as the Standard Gould Simplex Equipment, but it Should be Noticed that a Grid Resistance Bank Is Automatically Inserted in Series with the Lamp Circuit by a Voltage Relay when the Generator Voltage Rises to 74 Volts. This Increases the Capacity of the Lamp Regulator Two-Fold.

circuiting pile shown in the lower right-hand corner, which automatically cuts out the entire resistance of the lamp regulator carbons when the supply voltage falls equal to or below normal lamp voltage as occurs at every stop. At the top right-hand corner of the regulator panel board is shown the adjustable spring and lever which limits the pressure on the 3 carbon piles.

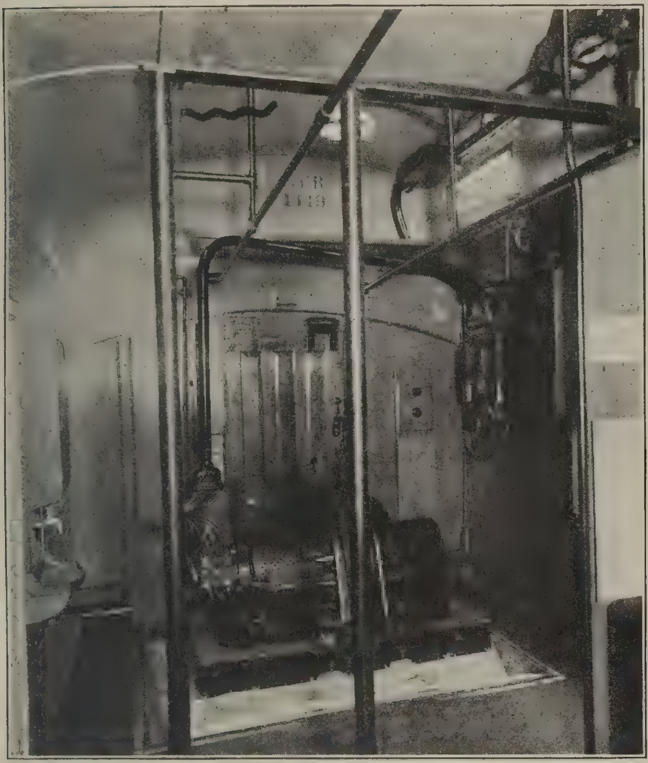


Fig. 6. Interior of the Dynamo Car with the Generator Case Removed Showing Canvas Gasket where the Generator Projects Through the Floor. Note the Generator Regulator Panel and Multiplier Panel with Auxiliary Resistance Grid in the Background at the Right.

It will be noted that these 3 carbon piles are placed in a triangular form and the compressing force is applied at the center of the pressure plate, which is in the form of an equilateral triangle. The pressure on the 3 carbon piles is equalized by means of an equalizing bar at the left end of the piles. This is also built in the form of an equilateral triangle, having a pivot bearing at the center so that if one pile is slightly longer than either of the others, this equalizing bar will tilt slightly so as to equalize the pressure, and consequently the current flow, through all 3 carbon piles in parallel.

As the generator voltage rises in charging the batteries and reaches a voltage of 74 volts, an auxiliary relay mounted on the center panel of Fig. 3 and wound to operate at this voltage, connects a "resistance bank" in series with the lamp regulator carbons of the main lamp regulator. This "resistance bank" then assists the carbon pile regulator in cutting down the generator voltage to normal lamp voltage and incidently removes a large part of the heating effect from the lamp regulator carbons, and practically doubles the voltage range of the regulator. On further rise in voltage, the lamp regulator carbon piles being automatically expanded, absorb this rise in voltage and maintain the lamp voltage constant. The carbon piles act so gradually and evenly that the lamp voltage does not fluctuate to any noticeable extent.

Storage Battery Control.

As mentioned before, there are at present three of these large axle generator train lighters in service, one of 20 k.w. capacity, and two of 17½ k.w. capacity, all operating at 80 volts. The 20 k.w. machine operates between St. Paul and Winnipeg and covers 10,582 miles per month; the two 17½ k.w. machines operate between Minneapolis and Duluth and cover 4,860 miles per month. The Winnipeg train has an average lamp load of 75 amperes at 66 volts, with a maximum lamp load of 130 amperes. This train is usually equipped with three 200 ampere hour, 9 plate lead storage batteries, each made up of 32 cells. The maximum load that has been handled by this machine to date was 220 amperes at 83 volts.

The Duluth trains have an average lamp load of about 65 amperes at 6 volts with a maximum of 105 amperes. The battery equipment on these trains is the same as the above. The lamp voltage regulation on all of the equipments is very satisfactory and at no time exceeds 1½ volts from normal.

As mentioned above, the storage batteries are all connected to a two wire circuit so that the batteries at the rear of the train will receive a somewhat lower voltage than that in the dynamo car on account of the line drop throughout the train line. This voltage drop from the control panels to the rear of the voltage train handled by these equipments is approximately 5 volts during peak load. Special provision has been made in order to compensate for this drop in train line voltage and to equalize the battery voltages throughout the train, both on charge and discharge. This consists of the resistance unit R′, Fig. 4, placed in series with the storage battery BD located on the dynamo car, as shown by the wiring diagram Fig. 4. The value of this resistance may be either determined experimentally or may be calculated, assuming a reasonable drop in train connector contacts. This resistance would have such a value that the voltages at both ends of the line would be approximately equal during peak load.

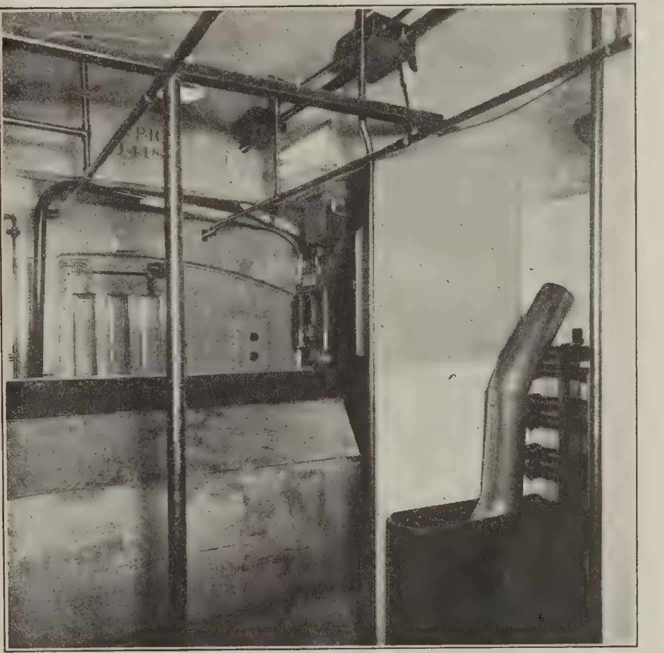


Fig. 7. Hinged Steel Casing Protecting the Generator. Baggage Can Now be Piled Around and on Top of the Generator Without Injury to It and Without Interfering with Its Operation.

In the circuit A. BD, C, Fig. 4, there is a drop in voltage across R′ equal to the drop in voltage across the resistance of both train lines 1 and 2 from the points I to K, K being the central point of the rear batteries. With a battery located at the center of the train, or near the forward end, this principle would not work out so well, in fact might require another resistance of a proportionately less value than that of the dynamo car battery, being placed in series with this battery.

Charging. Assume the generator to be operating at 80 volts. By test it has been found that on charge the voltage at BF, Fig. 3, is 77 volts with normal current flowing into the battery BR. The resistance R′ is then so adjusted that the voltage at "H" is also set to be 77 volts, then any reduction in current, due to the tapering effect of the battery charging at constant potential, will also result in a reduced voltage drop, both over the train lines 1 and 2 through the battery circuit resistance R-1. This will allow the terminal voltage at both of the batteries to be raised slightly with a reduced current, but it should be noted that this rise will be uniform on both batteries. As both of the batteries are finally brought up to their full state of charge, the taper charging effect will cause the current in each to taper off to a very low value and this will be done to an equal amount in each case.

Discharge. On discharge, when the forward loop connection is made on the train lines, by the automatic switch, connecting the train lines 2 and 3, the current from the rear battery then must traverse the entire length of the train through line 2, whereas the battery current from the forward battery connects directly across the lamps without traversing the train line 2. In other words, the effective voltage of the battery or batteries at the rear of the train, would be diminished by an amount equal to the voltage drop in the train lines 1 and 2 and be somewhat lower than the terminal voltage of the forward battery. Therefore, the same resistance R′ operates equally well to reduce the voltage of the battery BD on discharge as on charge and causes the rear batteries to assume their proper portion of the lamp load.

Where other batteries of the train are located at the center or near the forward end of the train as frequently occurs on a long train having one or more dining cars, these batteries would each require a resistance similar to that in the circuit of the dynamo car battery, but of a proportionately smaller value. Obviously if a battery on a diner located near the center of a train were not so protected by a resistance in series with it, this battery would receive a higher voltage on charge than either the front or the rear battery, and would similarly deliver a higher voltage on discharge than either the front or rear batteries. This battery, accordingly would assume an undue proportion of the current, both on charge and discharge and might be severely overworked on discharge and subsequently seriously overcharged.

The operation of this scheme could be improved by adding two additional cells to each storage battery on the train and raising the generator voltage about 5 volts to compensate for voltage loss in the line and the battery resistance. This same result could also be effected by employing a 60-volt lamp and setting the lamp regulator to operate at 61 volts instead of 66. As this would require carrying an extra stock of lamps, however, the addition of the 2 extra cells to each battery on the train would be simpler and equally satisfactory.

New York & Westchester Trains 99.2% on Time.

Figures based on the monthly report submitted to the Public Service Commission of New York, show that the New York, West Chester & Boston R. R. has maintained a splendid record for punctuality during the last year ending June 30, 1915. Of the 74,551 trains run only 627 arrived late, making 99.2% of all trains arriving at their destination on time. The maximum number of minutes late in any month was 1,442 minutes for April, the minimum number of 228 minutes late was the record for March. More than three-quarters of the delays are due to waiting for other trains, a cause which is beyond the control of the operating departments of the railroad. A large proportion of the delays were due to the opening of the draw bridge over the Bronx river. Very few delays were caused by failures of equipment or signals. Next to waiting for other trains, the greatest number of delays were due to waiting for other divisions, which is occasioned by the delay often necessary for the interchange of passengers between local and express trains.

One of the reasons for this fine record is the care which the railroad uses to discover and list any defects which may appear in the equipment. All factors which tend to cause the delay of the train are studied so as to prevent the recurrence of such an accident.

The averages for the year are: Trains run, 74,551; trains late, 627; trains on time, 73,924; per cent on time, 99.2%; average minutes late per train run, .093 minutes. The principal causes of delay are: Equipment, 1.5%; waiting for other divisions, 9.5%; waiting for other railroads, 77.5%; signals, 3.5%; other causes, 8%.

Pennsylvania Makes Good Record.

In the first six months of 1915 the Pennsylvania Railroad made more than 2,000,000 efficiency tests of all kinds, and 99.9 per cent of them showed perfect observance of all rules and regulations on the part of 135,458 employes.

Here are some results of this record:

Twenty-eight and one-half per cent less employes were killed in the first six months of 1915 than in the corresponding period of last year. This was not due to a heavy decrease in train mileage, as passenger train miles were only 6 per cent and freight train miles 8 per cent less than in 1914. In 1914, 119 employes were killed in the first six months from various causes, while in 1915, 85 employes were killed.

No passenger was killed in a train accident in the period covered by these tests—as a matter of fact no passenger has been killed in a train accident on the Pennsylvania Railroad since 1912.

A decrease in accidents is invariably accompanied by a high record of efficiency on the part of all employes, as shown in the efficiency tests which are made regularly. These tests cover the work of both officers and the rank and file.

The records for the first six months of this year show that 23,390 tests were made in the use of signals, and 99.4 per cent of them showed employes living up to the strict letter of the rules. Over 10,000 tests were made with signals set at stop, and in only 13 cases did the trains fail to stop before passing the signal by so much as a foot.

Rotary Converters for Battery Charging

The Illinois Central R. R. Co. has very recently installed a 30 k.w. converter of special design, known as the Martin converter, for charging storage batteries at their Weldon St. passenger coach yards. This new type of converter, which was described in the March, 1914, number of the RAILWAY ELECTRICAL ENGINEER, contains many novel features which seem to adapt it particularly to railroad service for storage battery yard charging systems, employing the constant potential method and for correcting power factor in large a. c. shop installations, and at the same time furnishing d. c. current for crane motors and variable speed tools.

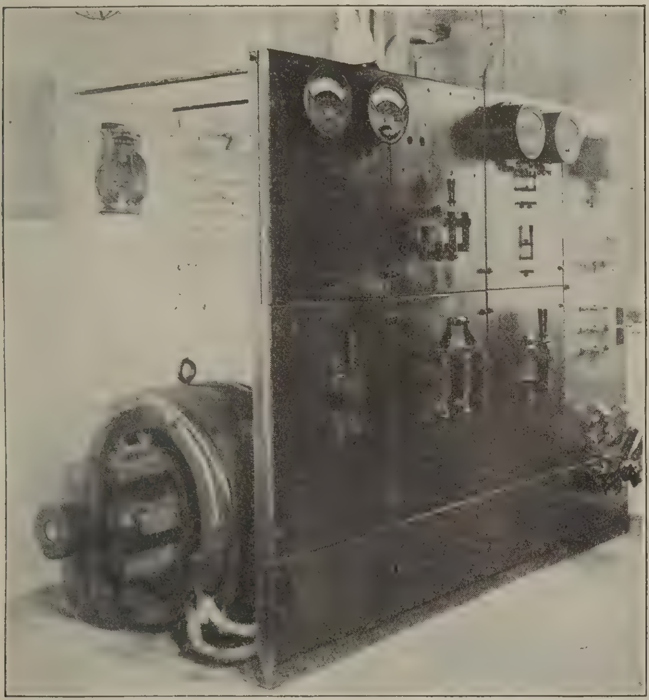


Fig. 1. View of the Converter and Switchboard. The Panel to the Right has Mounted on it the Starting Switches.

This converter, as installed at the Illinois Central yards, is a three-phase, 30 k.w. machine. Power is received from the main power house of the railroad at 220 volts a. c. and a three-phase transformer mounted in the rear of the board, steps this potential down too the proper point at the collector rings to deliver 92 volts at the commutator end of the converter. Several taps are brought of the transformer secondary winding, so that the voltage delivered to the converter and consequently the terminal charging voltage, can be set at the proper value.

It should be noted, however, as explained later, that the characteristics of the machine are such that there is no hand adjustment required, and that the voltage is maintained constant at this value provided the a. c. supply voltage is maintained constant. The voltage of 63 volts delivered at the three-phase slip rings of the converter produces a direct current voltage of 92 volts. This apparent paradox, which is typical of the operation of all converters, is due to the fact that the three-phase alternating current voltage measured by an a. c. volt meter is normally but .6421 of the maximum voltage of the d. c. supply line. In this machine the ratio of alternating to the d. c. voltage varies from about .58 to .67, due to the compounding effect of the machine, so the d. c. voltage is maintained constant in spite of the c. r. drop in the armature.

The Distribution System.

The distribution system is laid out on a three-wire double potential system, having two circuits of 45 volts each between positive and neutral and negative and neutral, and 90 volts over all. The power house is located near the center of the distribution system, and a main feeder line runs throughout the length of the yard. The positive feeder is carried directly to the south end of the yard, and the charging outlets tapped off on the return route, and the negative terminal carried to the north end of the yard, and similarly the charging outlets are tapped off at the return route. The neutral wire, on the other hand, feeds direct from the power house toward both ends of the yard. This

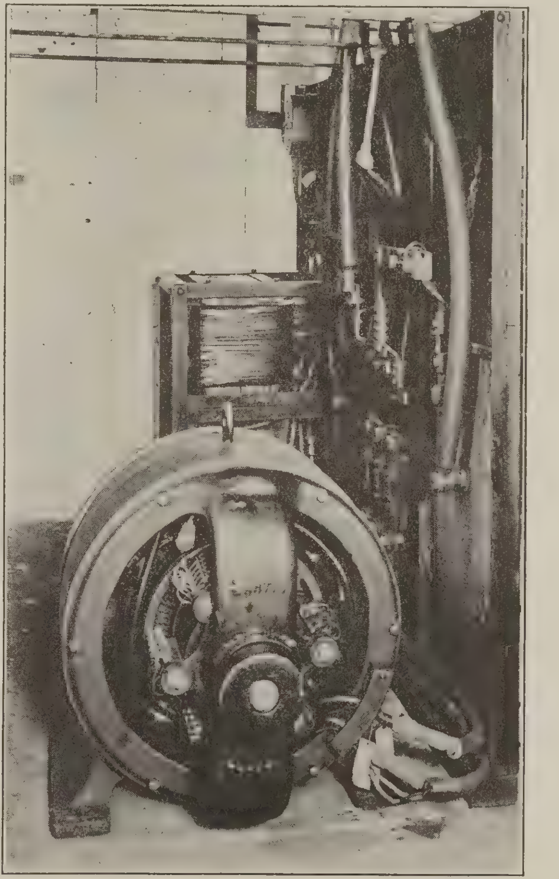


Fig. 2. Back View of the Same Board Shown in Fig. 1. The Three-Phase Transformer Is Shown at the Further End of the Board.

gives a constant potential system, both for the over all voltages between positive and negative, and the half circuit voltage between positive and neutral, or negative and neutral.

The main feeders are carried on overhead pole lines and a 45-volt charging circuit is lead off to under ground cross feeders at each pole. These cross feeders are tapped off alternately on the positive and negative side of the neutral, so as to balance the load and at the same time make it possible to obtain a 90-volt charging circuit for charging a 60-volt car by means of a double connector, having one wire run to the positive terminal of one charging outlet, and another wire running to the negative terminal of an adjacent outlet, either up or down the yard.

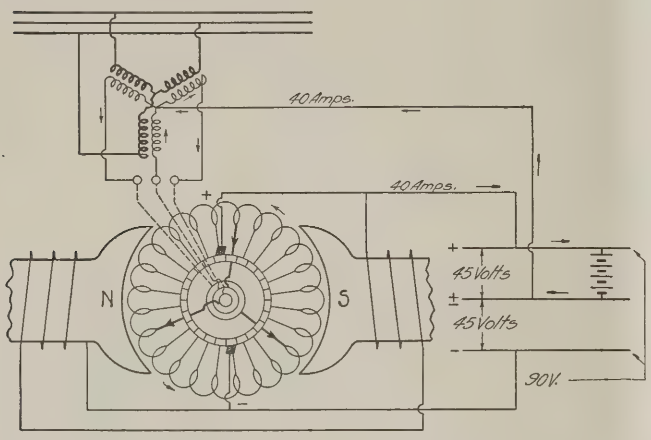


Fig. 3. Diagrammatic Sketch of a Two-Pole Rotary Converter Carrying an Entirely Unbalanced Load.

The transformer shown mounted on the rear of the panel board, Fig. 1, has the secondary coils star connected and the ntutral wire of the 45-90-volt d. c. yard charging system is carried direct to the neutral point of the transformer star connection. The operation of this feature of the installation is very interesting.

Fig. 3 is a diagrammatic sketch of a two pole rotary converter, which is loaded only on one side of the circuit, thus unbalancing the load. By following the arrows in the sketch it will be noticed that the current flows from the positive brush through the battery load to the neutral of the d. c. system, to the neutral of the star wound transformer. It then distributes itself through the three phases of the transformer and passes back through the slip rings into the armature. A 150% unbalanced load will not injure the machine nor seriously affect its operation.

The Converter.

This converter is of special design, and is known as the Martin rotary. It is manufactured by the Northwestern Electric Co., of Chicago. Although there are many features about it which give it very desirable characteristics, it is simply a modified rotary converter, so designed as to make it as near fool-proof as possible.

One of the principal features consists of a magnetic dampening ring inside of the pole pieces, which will prevent high voltages being induced in the field coils on starting. It might seem that this dampening ring, which is simply a series of punchings made up in the form of a hollow cylinder, would magnetically short circuit the fields of the rotary. On starting there is a heavy leakage of magnetic lines between the poles through the dampening ring, but when the machine gets up to speed this leakage is lessened. On either side of each pole slots are milled about half way through this ring, which tends to concentrate the flux emanating from the poles. If a machine is designed to be run at no load for a considerable portion of the time shunt windings are placed around the dampening ring to cut down the magnetic leakage, but when a machine is to be run loaded, except during the starting period, these shunt windings are eliminated and only series windings are placed around the dampening rings.

Fig. 4 shows a wiring diagram and section of a converter used for battery charging. As has been noted the dampening ring is slotted on both sides of the pole, and the series coils "B" are placed midway between the poles around the dampening ring. The direct current voltage increases with the effective width of the pole piece. These series coils control this effective breadth, for as the d. c. current increases the tips which lie on either side of the series coil are energized. Copper bars are embedded in the stator iron, forming a squirrel cage winding. Those bars of the squirrel cage winding which lie under the center of the pole pieces are replaced with iron conductors to increase the magnetic density of the center of the pole. This squirrel cage winding enables the machine to be started as an induction motor, and also prevents the machine from hunting during its operation. The compensating windings take the place of the original interpole of the direct current generator, that is, they keep the magnetic field of the machine from shifting under heavy load, and provide sparkless commutation.

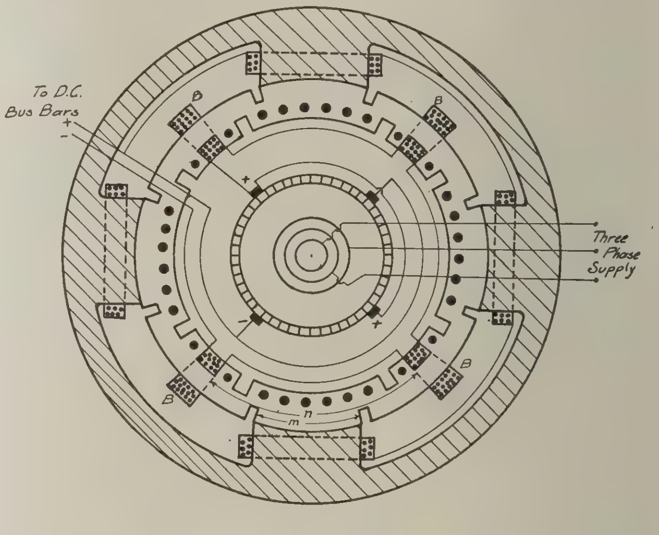


Fig. 4. Wiring Diagram and Section of a Three-Phase Rotary Converter Such as Is Used in Battery Charging. "N" Shows the Pole Breadth at Full Load and "M" at No Load.

The converter is started as an ordinary three-phase induction motor, or where a single phase converter is employed this is started as an inverted repulsion a. c. motor. This is done by short circuiting the fields on starting and applying line voltage to the brushes on the armature. Within two or three seconds after closing the switch it rises to synchronous speed, and this is indicated by the rise in d. c. voltage, as indicated on the d. c. volt meter. The starting switch is then thrown to the running position, and the converter then operates at synchronous speed, either three-phase or single phase, as the case may be.

When overcompounding of the direct current charging system is required, to make up for line loss in the yard charging system, etc., this may be provided by simply adding more series turns of wire over the coils "B" and the charging current passed through these coils, and at the same time placing the proper amount of inductance in the a. c. line. The compensating and starting coils are shaped so as to assist each other in regulating the machine. The spreading of the pole from the load current in the dampening ring winding maintains the d. c. voltage constant or increase, it depending upon the design, thereby making it unnecessary to work the pole pieces at a high magnetic density. Semi-closed skewed slots are employed in the armature to insure quiet running. In addition to the other special features of this machine it is provided with a new type of forced ventilation, which reduces the heating effect on overload, and accordingly improves the efficiency.

Where it is desired to have an adjustable d. c. voltage this can be accomplished by bringing several terminals from the secondary of the transformer to the base of the panel board, and by this means the d. c. voltage delivered to the rotary may be adjusted to the desired value. When a three-phase machine is employed three sets of transformer terminals will, of course, be brought to the panel board, and in making voltage adjustment the three connections should be adjusted to the same distance so that all phases in the converter will be at the same voltage.

Efficiency.

As is well known, the rotary converter is considerably more efficient than a motor generator set, on account of the fact that it has but one armature winding and one set of field coils, and because of the fact that but one armature is used, and motor and generator reactions tend to neutralize each other. Following is a series of tests made by the Commonwealth Edison Co., of Chicago, on this type of equipment.

Efficiency Tests

Machine Under Test.

One 35 K.W. Martin rotary converter and one 10 K.W. Martin rotary converter, used to supply direct current for battery charging service. The rotaries are operated on 220 volt, 3-phase system, delivering D. C. energy at 95 to 125 volts, the pressure being varied by means of a selector switch, which changes pressure taps in the transformer. Test was made to determine the commercial efficiency of these rotary converters in present conditions of operation.

Rotary Under Test.

35 K.W. 1,200 R.P.M. Martin rotary converter No. 1176.

First Reading.

Power required to operate rotary without D. C. load, 3,840 watts.

First Test.

A.C. power input, 36 K.W.
D.C. power output, 30.4 K.W. $\frac{30.4}{36} = 84.4\%$ efficiency
D.C. pressure, 98 volts.

Field resistance adjusted to give unity power factor at full load.

Second Test.

A.C. power input, 36 K.W.
D.C. power output, 30.38 K.W. $\frac{30.38}{36} = 84.4\%$ efficiency
D.C. pressure, 98 volts.

Field resistance adjusted to give unity power factor at full load.

Third Test.

A.C. power input, 40.8 K.W.
D.C. power output, 30.38 K.W. $\frac{34.18}{36} = 83.7\%$ efficiency
D.C. pressure, 96 volts.

Field resistance adjusted to give unity power factor at full load.

Fourth Test.

A.C. power input, 39.6 K.W.
D.C. power output, 34.5 K.W. $\frac{34.5}{39.6} = 87.1\%$ efficiency
D.C. pressure, 114 volts.

In this test field resistance was cut out, giving a capacity effect in A.C. receiving circuit.

Fifth Test.

A.C. power input, 37.2 K.W.
D.C. power output, 31.88 K.W. $\frac{31.88}{37.2} = 85.7\%$ efficiency
D.C. pressure 97.5 volts.

In this test, field resistance was cut out, giving a capacity effect in A.C. receiving circuit.

Sixth Test.

A.C. power input, 40.8 K.W.
D.C. power output, 34.31 K.W. $\frac{34.31}{40.8} = 84\%$ efficiency
D.C. pressure, 94 volts.

Field resistance was cut out, giving a capacity effect in A.C. receiving circuit.

Seventh Test.

Machine with half load,
A.C. power input, 22.8 K.W.
D.C. power output, 18.685 K.W. $\frac{18.685}{22.8} = 81\%$ efficiency
D.C. pressure 101 volts.

Field resistance cut out, same as previous tests.

Eighth Test.

Machine with quarter load,
A.C. power input, 13.2 K.W.
D.C. power output, 10.08 K.W. $\frac{10.08}{13.2} = 76.3\%$ efficiency
D.C. pressure, 104 volts.

Field resistance cut out, same as previous tests.

Rotary Under Test.

10 K.W. 1,800 R.P.M. Martin rotary converter No. 1177.

First Reading.

Power required to operate rotary with D. C. load 1,080 watts.

First Test.

A.C. power input, 10.2 K.W.
D.C. power output, 8.094 K.W. $\frac{8.094}{10.2} = 79.3\%$ efficiency
D.C. pressure, 92.5 volts.

Second Test.

A.C. power input, 12 K.W.
D.C. power output, 9.57 K.W. $\frac{9.57}{12} = 79.7\%$ efficiency
D.C. pressure, 110 volts.

Third Test.

A.C. power input, 12.48 K.W.
D.C. power output, 10.0 K.W. $\frac{10.01}{12.48} = 80\%$ efficiency
D.C. pressure, 110 volts.

Fourth Test.

A.C. power input, 7.2 K.W.
D.C. power output, 5.47 K.W. $\frac{5.47}{7.2} = 76\%$ efficiency
D.C. pressure, 119 volts.

Fifth Test.

A.C. power input, 4.45 K.W.
D.C. power output, 3.075 K.W. $\frac{3.075}{4.45} = 69\%$ efficiency
D.C. pressure, 123 volts.

Field resistance adjusted for unity power factor at full load in all of these tests.

Power Factor Correction.

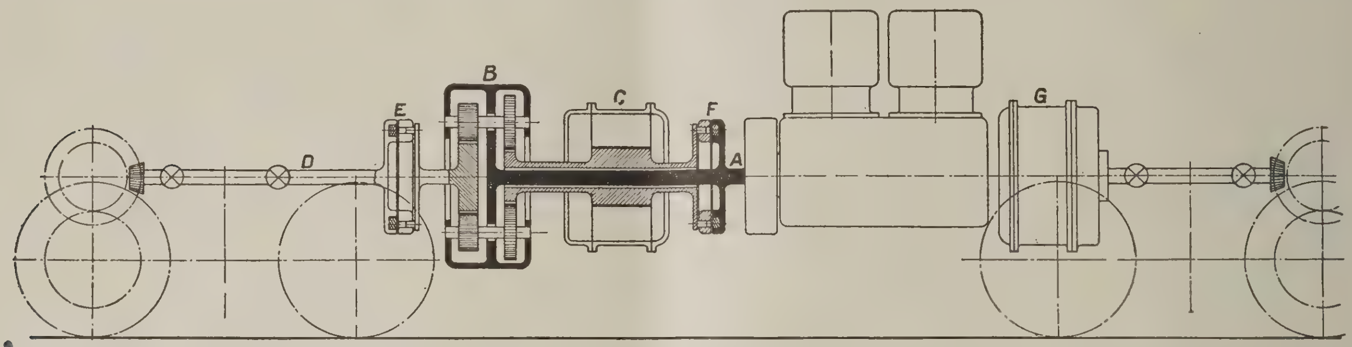
In many of the most recent large shop installations a synchronous motor generator set or converter is employed to correct the power factor and maintain it at approximately unity value, thereby eliminating wattless current, heat effect, power loss through the generator, transmission line, transformer motors, etc. At the same time this furnishes a very convenient supply of direct current for operating cranes, motors and variable speed tools. It would seem that with the higher efficiency of this rotary converter, in which the usual difficulties of high voltage, hunting, starting, etc., are eliminated, this type of a converter should find a wide application in this field.

Petrol-Electric Locomotive Coach

There is just being completed in the Midland Railway Coach & Wagon Company's works, Birmingham, England, a 200 h. p. petrol-electric locomotive coach which is being built by the Thomas Transmission Co., Ltd., to the order of the New Zealand government.

This is described by the Railway Engineer as being built for the 3 ft. 6 in. gauge, and in the tests which were recently made upon it, pushed empty and loaded coal trucks, the gross load aggregating 120 tons. This performance was considered satisfactory in view of the fact that the machine is geared for a top speed of 40 m.p.h. On traveling alone it showed a very high acceleration, reaching a speed of 20 m.p.h. on the 120 yards of available track.

In the accompanying diagramatical sketch the principal units of the equipment are shown. This can best be described in the maker's own words.



A Engine Drive to B Planetary Gear Casing. C Electric Machine Connected to Small Sun Wheel. D Mechanical Drive to First Bogie. E. Magnetic Clutch for Free Wheeling Purposes. F Magnetic Clutch for Direct Drive at Top Speed. G Second Electrical Machine Driving Second Bogie.

> The engine driving shaft A is permanently connected to the casing B of the planetary gearing. This casing carries a set of planet wheels on two spindles which are supported in roller bearings in the sides of the casing. Each spindle has rigidly fixed to it two planet wheels of different diameters, and these in turn mesh with two sun wheels. The larger sun wheel drives the outside axle of one bogie through the free-wheeling magnetic clutch E and the driving shaft D. The final drive to the axle is by means of a bevel and spur reduction. The smaller sun wheel is connected direct to the armature of the first electrical machine C, and a second magnetic clutch F is provided for locking the planetary gearing.
>
> The second electrical machine G is located on the opposite side of the engine, and drives the outside axle of the second bogie by means of a cardan shaft and a bevel and spur reduction, as in the case of the first bogie.
>
> In order to start the engine the clutch E is disengaged and the clutch F engaged. This locks the gearing, and the first electrical machine C is thus locked solid with the engine, so that when the battery provided for the purpose is connected across the series machine C the engine is caused to rotate and starts up.
>
> In order to understand the action of the gearing, let it be assumed that both clutches are disengaged. When the engine drives the casing B a differential action is set up between the large sun wheel and the small sun wheel. The large sun wheel tends to rotate forwards in the same direction as the engine and the small sun wheel tends to rotate backwards in the opposite direction to the engine. If the clutch E is engaged then the large sun wheel will be held stationary as it is connected direct to the load, and as the small sun wheel is free it will rotate backwards at about the same speed as the engine rotates forwards. If current be taken from the machine C the motion of the small sun wheel will be retarded, so that the large sun wheel. i. e., the load, must begin to move. By manipulation of the field of the machine C this action can be continued until the small sun wheel is practically brought to rest, and the large sun wheel caused to rotate at about half engine speed.
>
> motor, drives the second bogie electrically. It is clear, therefore, that there is a mechanical drive to the first bogie and an electrical drive to the second bogie.
>
> The next operation is to gradually increase the speed of the large sun wheel until it reaches the engine speed, so that the gearing can be locked solid by means of the clutch F, and a direct drive obtained for top speed.
>
> This speeding up of the large sun wheel from half speed to top speed is obtained by changing the functions of the two
>
> During this initial period the current from the machine C is transmitted to the second machine G, which, acting as a electrical machines and causing G to act as a generator and supply current to C as a motor, driving the latter in the same direction as the engine. This operation is a gradual one, and is carried out by manipulation of the field of the machine G. When the sun wheels and the casing have reached a common speed the magnetic clutch F is engaged, so that the electrical transmission is cut out altogether and a direct drive obtained from the engine to the first bogie.
>
> When the vehicle is traveling on top speed the two electrical machines C and G are inoperative and can be used for any useful purpose. It is convenient to use them at this stage for charging the battery, which is used for starting up the engine and lighting the vehicle. It must be pointed out that this battery is never used at any time for assisting in the propulsion of the vehicle.
>
> As the vehicle has to travel equally well in either direction it is necessary to provide a reversible engine, but for shunting and reversing for very short distances an emergency reverse is provided, which works in the following manner: The clutch E is disengaged and the clutch F engaged, so that the machine C is locked solid with the engine. Current is then taken from this machine as a generator to the second machine G acting as a motor with a reversed field, and the vehicle driven purely electrically from the second bogie in the opposite direction.

Electrification in Boston District Recommended.

W. B. Bennett, engineer of the Wisconsin Railroad Commission, makes some comprehensive recommendations for the electrification of railroad lines centering in the district of Boston, in a report following and investigation of the transportation facilities in the metropolitan district of this city. The roads considered would be Sangus and Medford branches of the Boston & Maine, and the West Rocksbury branches of the New Haven, besides the Newton circuit of the Boston & Albany.

Under the plan proposed, through steam trains might still be operated on the railroads, while local trains which make frequent suburban stops would be operated by electricity. About $15,000,000 will be required to carry out the plan suggested.

Shop Motor Section

Speed Control of Induction Motors

By J. H. Wickman

Ninth Article.

The best and only practical type of polyphase motor that will operate at variable speeds, with the exception of the two-speed motors which have been described in previous lessons, is the slip-ring motor having a wound rotor. The method of starting induction motors as described in the July issue is too uneconomical to be used as a means of speed variation. Inserting resistance in the primary cuts down the starting current but this method is not suitable for speed regulation as there is a certain critical speed at which the torque is not great enough to carry the load and the motor will stop. The use of an auto-transformer is more economical but is open to the same objection as using resistance. The most practical way to vary the speed is to insert resistance in the rotor circuit.

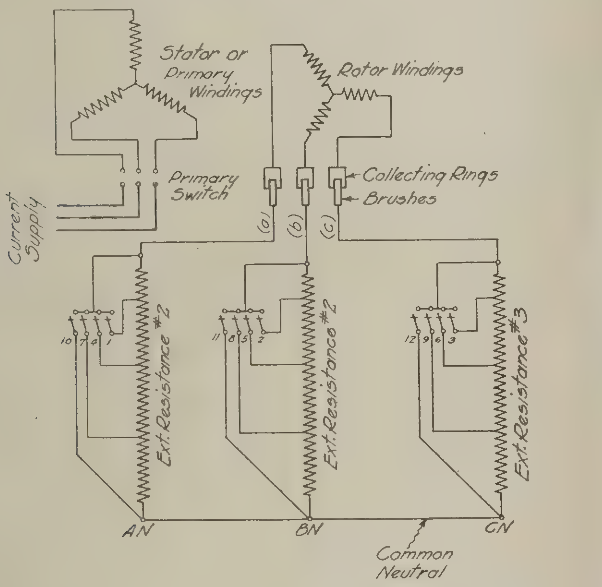


Fig. 21. Diagrammatic Sketch Showing Method of Starting an Induction Motor by Inserting Resistance in the Rotor. The Single Pole Switches Are Closed in the Sequence of Their Numbers.

When the switch is closed, completing the primary circuit of a polyphase induction motor, the current which then flows in these windings sets up a rotating magnetic field. This magnetic field cutting the windings of the rotor induces a secondary voltage in it in the same way that a secondary voltage is induced in a transformer. When the rotor is running at synchronous speed there is no voltage induced in the rotor, so no power can be delivered by the shaft, as soon as the rotor begins to slip, however, current will flow in the rotor and power will be delivered to it. So the greater the slip of the shaft, the greater the induced voltage, and according to Ohms law the greater the current that will flow. It naturally follows that the more resistance present in the rotor the greater will be the slip for more voltage will be required to drive full load current through the rotor. Obviously then, the motor that would have the greatest torque for starting would be the one having the most rotor resistance. To illustrate, if the slip is 10 per cent with a certain resistance it will be 30 per cent with three times that resistance, providing all other operating characteristics remain the same. The torque of an induction motor is constant regardless of the resistance in the rotor. The only disadvantage of this method is that power is lost in the resistance. The principle of operation of a motor which is started and controlled by inserting external resistance in the rotor may be better understood by referring to Fig. 21.

The several single pole switches numbered 1, 2, 3, etc., up to 12, and the main primary switch are all opened when the motor is stopped. It is started as follows: Close the primary supply switch, after the motor begins to rotate close the several small switches consecutively in the order of their numbers. As will be seen from following out the windings each small switch cuts out a portion of the external resistance, switches 10, 11 and 12 cutting out all the resistance. The slowest speed would be obtained with all the secondary switches open, a faster speed with switches 1, 2 and 3 closed, 4, 5 and 6, 7, 8 and 9 each being progressively faster, and 10, 11 and 12 being the fastest.

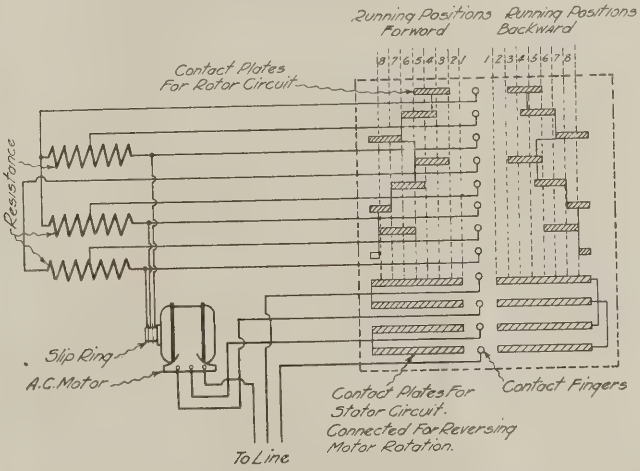

Running Positions Forward
Running Positions Backward
8 7 6 5 4 3 2 1
1 2 3 4 5 6 7 8
Contact Plates For Rotor Circuit
Resistance
Slip Ring
A.C. Motor
To Line
Contact Plates For Stator Circuit. Connected For Reversing Motor Rotation.
Contact Fingers

Fig. 22. Type of Motor Starter Used for Reversing Motors. The Shaded Portions Are the Contact Plates.

Another method of speed control would be to cut the external resistance out of one phase altogether and then vary the speed from intermediate to full speed by controlling the resistance in the other two phases. This method is not recommended, however, as it results in a very poor power factor and poor efficiency. It finds its principal application for laboratory and experimental purposes.

Application of A. C. Motors to Variable Speed Machinery.

Such machines as planers, cranes and lathes that require a variable speed drive are often equipped with this type of motor where alternating current only is accessible. It must be borne in mind that the variation in speed is only obtained by wasting the excess energy in external resistances, for a given torque at a low speed will require that same amount of power as for full speed. For this reason it is considered good practice with shop men to install gearing for use with this type of machinery so that the intermediate speeds can be obtained while the motor is running at its most efficient speed. In such cases where direct current is available the series-wound motor will be found more applicable to crane service where a great many short lifts have to be made. Compound wound direct current motors with an adjustable shunt field will be found to give better service for planers and slotters if an alternating current motor could not be run at its maximum speed most of the time.

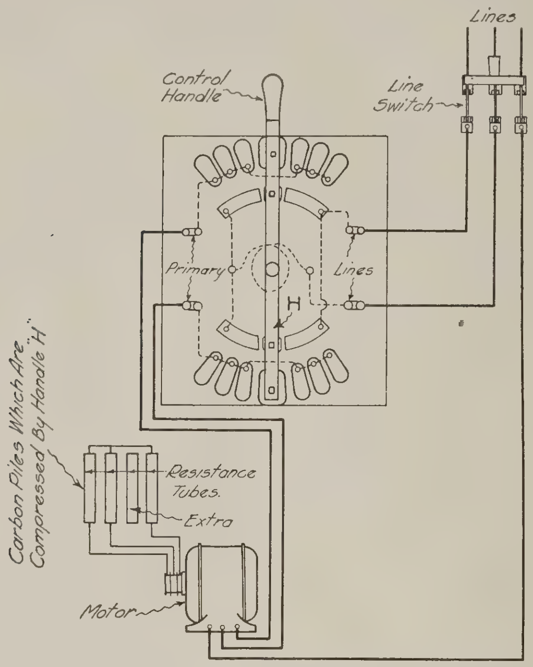


Fig. 23. Carbon Pile Speed Controller Which Varies the Speed of the Motor by Inserting Resistance in the Secondary Circuit.

Variable Speed Reversing Motors.

Around railroad shops where alternating current is used exclusively and it is necessary to run cranes, turn-tables, elevators, hoists and other machinery that must run in either direction, a special type of controller must be used. In a three-phase motor, to reverse the direction of rotation it is only necessary to reverse two of the primary connections.

The type of controllers built by several large manufacturers for reversing motors resembles a common street car controller in external appearance. A controller of this type is shown diagrammatically in Fig. 22. This shows the complete wiring connections that are used with a low voltage drum type controller. The cross-sectioned portions represent the contact plates. Those at the bottom switch the primary circuit so that the motor will run in either direction, depending on which way the controller handle is moved. These contact plates are so placed that the speed will be the same in No. 1 operating position whether the motor is running forward or backward. In fact the starting and operating characteristics are the same for operation in either direction.

This type of controller requires a minimum amount of repairing, the chief wearing parts being the contact fingers and plates. As these become worn they can either be smoothed up with a file or replaced.

Carbon Pile Controllers.

Another type of controller that regulates speed by varying the secondary resistance and extensively used for the control of slip-ring motors is the Type W Controller made by the Allen-Bradley Co. This has given very good results. The primary reversing switch and the secondary resistance, consisting of piles of carbon discs, are all mounted in a compact iron case.

When the operating handle is thrown into either the forward or backward operating position the correct primary connections are made and if the handle is thrown to the more extreme position the carbon discs are compressed which reduces the resistance of the secondary and allows the motor to come up to full speed.

The wiring diagram shown in Fig. 23 shows this type of controller. The advantage of this over the one shown in Fig. 22 is in its simplicity, cost of installation and smooth control. The speed can be varied to any value within the range of its operation by properly adjusting the pressure on the carbon piles.

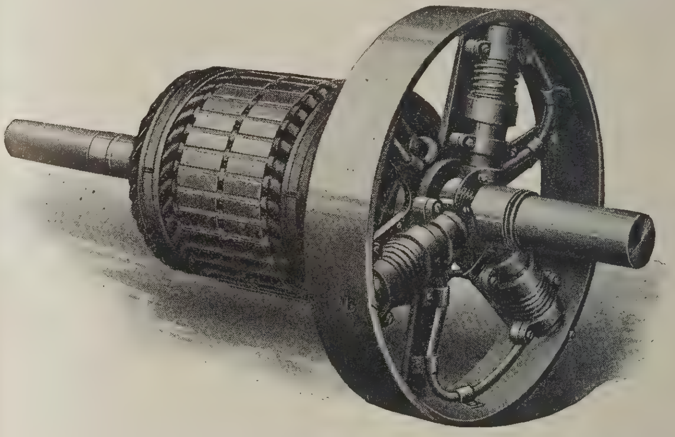


Fig. 24. Combined Rotor and Starting Element. Centrifugal Force Acting on the Carbon Piles in the Spokes of the Pulley, Cuts Out the Rotor Resistance as the Speed of the Machine Increases.

New Type of Automatic Starting Motor.

Before leaving the subject of A. C. motors and starters it is fitting to say a word about a new type of motor which contains an automatic starting element. Simply closing a line switch is all that is necessary to start this motor.

The rotor of the motor is phase-wound similar to other slip-ring motors except that in the place of slip-rings and brushes a starting device is built as part of the rotor. This consists of three carbon piles which are connected into the rotor circuit. The pressure on these carbon piles is automatically controlled.

Fig. 24 shows the rotor and starter. It will be noted that the three ends of the rotor winding are brought out to the three insulated carbon piles. As the rotor begins to rotate, centrifugal force compresses the carbon piles and decreases the secondary resistance thus bringing the motor up to speed evenly and gradually. Some of the advantages of this type of starter over the ordinary types of A. C. starters are as follows:

1. Reduced installation costs.
2. Can be operated on lighting circuit without severe voltage fluctuation.
3. It is suitable for constant speed and for starting under heavy load.
4. A "no-voltage" release is not required as it automatically sets itself for starting when it stops.
5. It is adaptable for remote control work.
6. Wiring simplicity.
7. No external resistance required.
8. Low maintenance cost.

The Principles of Alternating Currents

Williard Doud

Fifth Article.

Capacity.

Capacity is a measure of the energy which a circuit is capable of storing when a certain pressure is exerted on it. When an alternating current flows through a conductor which is capable of storing energy, the back voltage due to the stored energy will continually oppose the impressed voltage. The net result in the circuit is a current of lesser value, the E.M.F. or voltage values of which do not correspond with those of the current, but lag behind them, or as is usually said the current leads the voltage.

Capacity may be illustrated in a hydraulic circuit by means of an elastic diaphragm placed in a chamber, the two ends of which are connected to a piping system and pump. Such an arrangement is shown in Fig. 20.

If pressure is applied on one side of the piping as indicated by the arrow, the current will flow into the chamber until the elastic diaphragm is distended sufficiently to produce a back pressure equal to that of the line pressure at which point no additional current will flow.

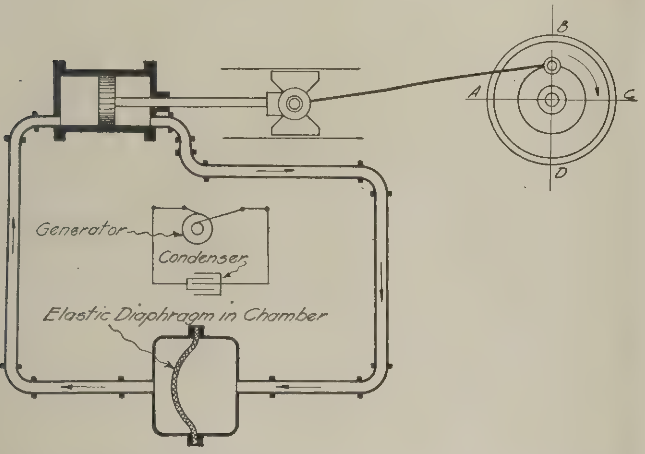


Fig. 20. An Elastic Diaphragm Placed in a Chamber the Two Ends of Which Are Connected to a Pump Through a Piping System, Illustrating Capacity. Small Sketch in Center Shows a Similar Electric Circuit.

If the chamber could be removed from the pipe line in this conditions the piping leading to the two sides being closed off tightly with suitable valves, the chamber would retain its pressure which would be released if the ends of the pipes were connected together and the valves opened.

An electric condenser acts in a similar manner when a voltage is impressed across its terminals. A charge accumulates in the condenser until its back pressure is equal to the voltage in the circuit to which it is connected. Disconnected from the line it retains its energy which will be discharged and equalized if the ends of the circuit are connected together with a conductor. When an alternating current is applied to the condenser or chamber in the hydraulic circuit the current will flow very rapidly into the chamber until the counter pressure due to the distended diaphragm begins to oppose the flow. Thus it will be seen that the current will flow rapidly while the pressure is low and a smaller flow when the pressure is maximum because at this point the diaphragm is already tightly distended. The maximum current precedes the maximum pressure, and a leading current is the result.

The flow and discharge of an alternating current into and out of a condenser in a circuit follows exactly the procedure outlined above.

Phase displacement of the current from the voltage results in wattless or idle power and the use of the elastic diaphragm and chamber shows very clearly how the power delivered to a condenser returns to assist the movement of the piston in the opposite direction.

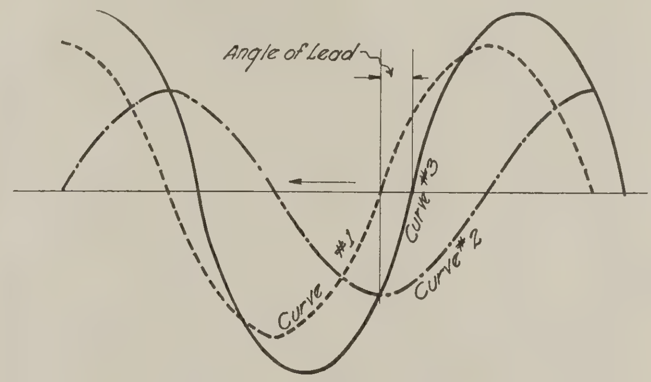


Fig. 21. Curves Showing the Relation of the Different Voltages in a Circuit Containing Capacity.

The action of a condenser on an electric current which is displaced from the voltage is to produce a motor action on the generator, during part of the cycle and to absorb an equal amount of power in the other half of the cycle, thus requiring less power for its operation. So in this way a generator may be delivering full load current at the proper voltage and still be delivering but little or no power for the reason that most of the power delivered by the generator is returned during the same cycle.

Fig. 21 is a series of curves showing the effect of capacity or condenser reaction in an alternating current circuit.

Curve No. 1 represents the voltage or E.M.F. consumed in resistance. Curve No. 2 is the counter E.M.F. of the capacity or condenser reaction and curve No. 3 is the total voltage impressed on the circuit. In this case as with the circuit containing inductance the current is in phase with the voltage consumed in resistance and has values proportional to same.

A study of the curves shows that No. 1 leads curves No. 3 and has a lesser value and differs in phase, or step. Curve No. 2 lags behind both curves No. 1 and No. 3 and has lower values.

Concerning condensive or capacity effect it may be said that with this condition present in a circuit, the current leads the voltage and therefore differs from inductive effect in which the current lags behind the impressed voltage. In contending with capacity and inductance in an alternating current circuit the wattless or idle currents resulting from these influences, are passing through the circuit and reduce the ability of the generating unit to handle its full rated load since a certain portion of the conducting medium of the circuit and generating coils must be utilized for carrying these idle currents. Fortunately these effects counteract one another so by properly proportioning inductance and capacity their effects can be almost entirely eliminated.

Since the effect of wattless current is to reduce the ability of an alternating current circuit to perform useful work, it has an important bearing on size of the conductors and generators required for a given service. It is evident, therefore, that some method must be available to determine the relation of useful to wattless or idle current and its measurement and this phase of the situation will receive our attention in the next installment.

The Railroad Electricians' Club

The New York Electric Car Lighting Association

On May 27, 1915, a large number of car lighting men located in New York City and vicinity met in the rooms of the American Society of Mechanical Engineers and organized the "New York Electric Car Lighting Association." The organization starts out with a charter membership of 60, and it is expected that this will reach the 200 mark before the annual meeting, which is to be held the first Tuesday in October.

It is stated by the secretary that the object of this association is the advancement of knowledge concerning the principles, construction, repair and service of railway electric car lighting equipment by discussion, exchange of information, investigations and reports of the experiences of its members; and to provide an organization to which the members may agree on such joint action as may be required or desirable to give the greatest efficiency to railway lighting equipment intrusted in their care.

At the June meeting of the club the subject for discussion was "Battery Current Regulation versus Current Regulation for Axle Lighting." The meeting was poorly attended on account of inclement weather, so the subject was not very thoroughly discussed, and same was placed on the table for another meeting. The subject of the meeting for July 6 was "Proper Maintenance and Applying of Belts and Alignment of Generators."

The officers of the association are as follows: G. Wall of the Lackawanna R. R., president; F. C. Dunlap, Pullman Co., first vice-president; H. Sunderland, New York Central R. R., second vice-president; A. J. Prettyman, Grand Central Terminal Co., secretary; T. C. Case, Grand Central Terminal Co., treasurer. The executive committee consists of the officers and following men: C. Dobbs, Penn. R. R.; Mr. Harper, Pullman Co.; J. Scudder, Grand Central Terminal Co.; F. E. Hunt, New York Central R. R.

The dues of the association are $1 per year, including active, associate and supply men. The regular meetings of the club are to be held on the first Tuesday of every month and it is hoped that all car lighting men in the vicinity of New York will become active members of the club.

Edison Storage Battery Questions

Continued from last month

Gravity of the Situation.

Q. 27. What will happen if the gravity of the solution is allowed to go too high or too low, either due to overflushing or lack of flushing or other causes?

Ans. 27. If the level of the solution is allowed to get below the top of the plates this will both increase the resistance of the cell and the current density over the surface of the plate. This will cause injurious heating of the cell which may even become high enough to fuse the plates if the level of the electrolyte falls to within an inch or so of the bottom of the cell.

The cause of too strong electrolyte can only be flushing with electrolyte instead of distilled water to replace evaporation. It will be found strong also, however, if measured with solution below the proper level. Strong electrolyte has a tendency to lower the voltage of discharge, and it may also set up strains in the active material that will tend to burst the tubes of the positive plates.

If the gravity of the solution is allowed to get too low either because of improper flushing or because the battery is allowed to go too long before renewing the solution it will cause the internal resistance of the battery to be higher than normal and this will cause undue heating in the battery and also prevent the battery from delivering its full voltage and full capacity. There will be no injurious chemical effect of this weak electrolyte on the plates, however.

Normal Rate.

Q. 28. What is the normal rate of the standard A-8-H train lighting battery?

Ans. 28. The normal current rate for the standard A-8-H train lighting cells is 60 amperes.

Effect of Low Rate Charging.

Q. 29. What is the effect of charging the battery at a low rate, and what is the lowest rate that may be employed with good results?

Ans. 29. The battery should be charged at ⅔ normal rate or above, particularly at the beginning of charge. For the standard car lighting battery, the A-8-H size, this will require a charging current of at least 40 amperes. If the battery is charged at a rate lower than this, the voltage on discharge will be uniformly low throughout the entire discharge. If lamp load is small this will be compensated for by the smaller drop.

Q. 30. Can the battery be brought up to full capacity by charging at a low rate?

Ans. 30. It is true that the battery can be brought up to full capacity in ampere hours by charging at the low rate as is done in signal work. The charging voltage under these conditions will be low and, as explained in the above problem, the discharge voltage will be correspondingly low. While this may be satisfactory for signal work where voltage is not so important a factor as current and total power available, it is of far greater importance in car lighting work, where a high discharge voltage is desirable.

Axle Lighting System Best Adapted to Edison Battery.

Q. 31. Since the Edison car lighting battery should be charged at at least 40 amperes, particularly at the beginning of charge, what methods of charging with an axle lighting system is to be preferred, that is, is it better to employ constant generator current regulation, battery current regulation, or constant potential regulation?

Ans. 31. In order to answer this question we must for a minute consider the principles of the three methods of axle generator battery charging.

Where the regulator controls the generator output to constant value, the battery charging current is simply the difference between current used by the lamps and the total generator current. If all lamps are turned on, the current to the battery will either be very low or in some cases there might even be a slight discharge from the battery. On the other hand, if all lamps are off, the current to battery may be very heavy, for it will then receive the total generator output.

With the constant battery current regulator the current flowing to the battery is maintained at a definite fixed value regardless of current required by the lamps, the total generator output increasing and decreasing as the lamps are turned on or off.

With the combination current voltage regulator the battery current is at first controlled to constant value by the current regulator, but as the voltage on charge soon rises to the limit set by the voltage regulator the current begins to taper off and reaches a low value at the end of the charge.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 43

Gould Simplex System—Dismantling the Generator

Removing the Armature.

If it is desired to simply remove the armature so as to get at the field coils or some other internal parts of the machine, it is not necessary to remove the pulley end housing from the armature shaft, in which case the six cap screws of the pulley end housing should be removed, but the nuts of the bearing plate should not be disturbed.

The commutator end inspection plate should then be removed and the hollow wrench screwed into the bushing of the bearing, as shown in view "F", Fig. 212. A few turns of the cap screws with a hand wrench will then force the armature shaft out of the tapered fit of the bearing and at the same time will force the pulley end housing off the other end of the machine.

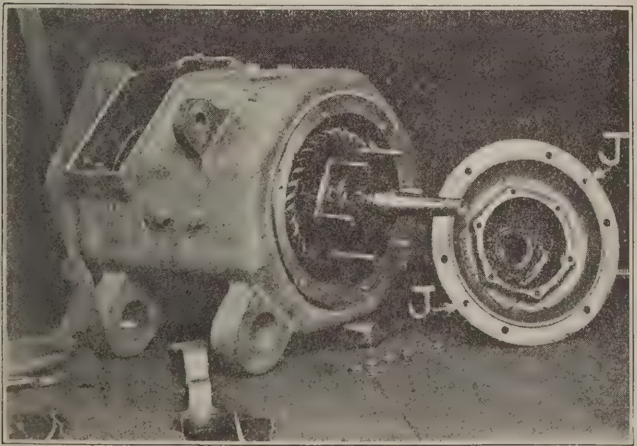


Fig. 212. Generator with Pulley End Housing Removed. After Removing the Six Cap Screws, and the Six Bearing Plate Nuts, Two of Them Are Screwed Into the Head at the Points "J" So the Head Can Be Forced Off.

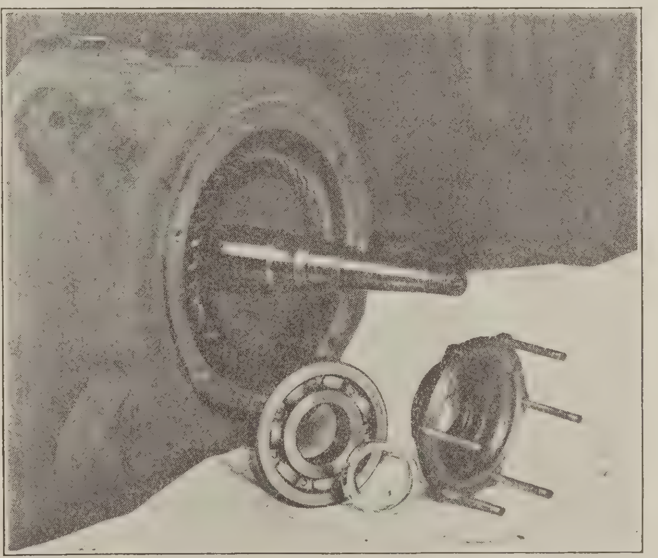


Fig. 214. The Bearing Lock Nut and Bearing Plate After Having Been Cleaned.

In case one of these hollow wrenches is not available, the armature can be removed by screwing the two cap screws into the tapped holes JJ in the pulley end housing, but care should be taken not to screw these up too tight, as this would be liable to break a piece out of the housing at this point. After having tightened these cap screws until you have applied quite a strain on the pulley end housing, with a block of hardwood and a hammer strike the commutator end of the shaft. With the strain already applied at the rear end housing by the cap screws, a few sharp blows applied at the commutator end of the shaft will be sufficient to start it out of the tapered fit of the bushing.

To Remove the Armature from the Shaft.

After the armature has been stripped free from the machine the shaft can be removed by first taking off the spring ring (21), Fig. 218, which is simply held in place by a groove in the shaft. The nut lock (22), with dowel pin (23), Fig. 218, can then be removed by screwing two pullers into place. If pullers are not available, machine screws of proper size will serve and the nut lock can then be pulled out with a pair of pliers, gripping the screws. The castellated nut No. 24, Fig. 218, can then be unscrewed with an armature nut wrench which is provided with prongs for fitting into the castellations of the nut and is squared at the outer end to receive a wrench. The shaft can then be removed from the armature in the ordinary way, by bumping it on end on the floor, and care should be used so as to strike square with the shaft perpendicular so as not to bend the shaft.

Applying the Armature to the Shaft.

The shaft should be pushed into the armature from the pulley end of the same; the shaft and armature are then tipped up vertically and then bumped on the floor until the armature is driven home against the shoulder on the armature shaft.

The armature should be laid down so that the key in the shaft comes on top and the castellated nut should then be screwed on the shaft under the commutator turned up tight. Before turning this quite as far as possible, however, care should be taken to see that the keyway of the armature shaft lines up in one of the three positions as follows:

(1) With a castellation directly in line with key, as shown in diagram "X," Fig. 219.
(2) With right edge of the key lined up with the left edge of the castellation, as shown in diagram "Y," Fig. 219.
(3) With the left edge of the key lined up with the right edge of the castellation, as in diagram "Z," Fig. 219.

If the castellated nut is not lined up in one of these three positions it will be impossible to apply the nut lock so that one of the keyways will fit over the key in the shaft and at the same time the dowel pin enter one of the castellations. The key holds the nut lock from turning on the shaft and the dowel pin keeps the castellated nut from turning under the nut lock; the nut lock in turn is held in place by the spring ring. It will be noted that there are three key ways in the nut lock and if the key lines up evenly with a castellation as in No. 1 above diagram "X," Fig. 219, the nut lock should be applied, using the center keyway. If the castellated nut lines up as in No. 2 above, diagram "Y," Fig. 219, use the left hand keyway. If the castellated nut lines up as in No. 3, diagram "Z," use the right hand keyway.

For the benefit of the boys who are interested in learning why this is so we will go into further details: It will be noted that the castellations of a nut are the same width as the keyway and that the solid projections of the nut are just twice the width of the keyway. In other words, there are three positions of a castellated nut in being turned from one castellation to the other, as given under 1, 2 and 3 above, and as shown in positions "X," "Y," and "Z" of Fig. 214.

If the castellated nut becomes tight at the position 1, as in the diagram "X," the nut lock can be applied by using the center keyway, in which case the dowel pin comes opposite the key in the shaft and in this position will enter the castellation as shown.

For the purpose of illustrating this we will divide the castellated nut into 18 equal parts, of which six are castellations numbered 1 in the diagram, Fig. 214, and the other twelve are solid portions of the nut numbered 2 and 3, as shown. It will be noted that while a castellation comes in every third position on the castellated nut, the three keyways on the nut lock are set four positions apart. Assuming then that after having brought the castellated nut to the No. 1 position, it was found necessary to tighten it a little further so that the No. 2 position comes opposite the key as in the diagram "Y." In order to have the dowel pin come into this castellation, the nut lock would also have to be turned forward one division; but there is no keyway to fit the key in that position, for this would bring the keyway adjacent to another keyway, which would be no keyway at all, but an open slot. Therefore, we jump three spaces into the next castellation, which is the fourth space away from the original position. Therefore, the keyways in the nut lock are set four spaces apart.

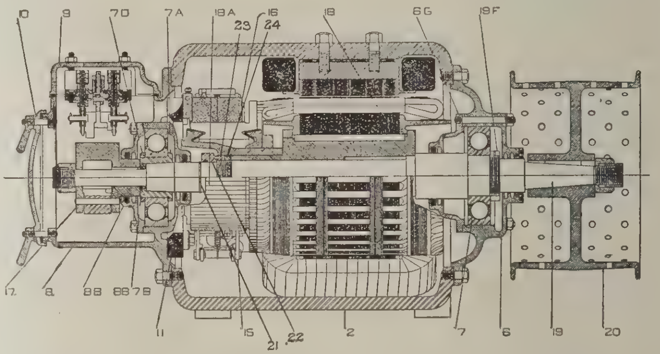


Fig. 218. Sectional Diagram Through the Generator.

If it is found, however, that one division does not sufficiently tighten the nut, so that it has to be moved so that position No. 3 is opposite the key as in diagram "Z," this would mean that the castellated nut has been tightened two divisions from its original position No. 1 diagram X.

There is, of course, no keyway in the nut lock to correspond with advancing the dowel pin two divisions, but it will be noted that turning it back one division brings the dowel pin into a castellation. Therefore, if the nut lock is turned back to the left 4 divisions from its original position No. 1 diagram "X," or 8 divisions from its second position "Y," so that the right hand keyway of the nut lock slides over the key, the dowel pin will enter the castellation to the rear, as shown. It will be noted that the dowel pin is always opposite the center keyway on the nut lock.

The Field Coils.

When it becomes necessary to remove a generator field coil or pole piece this can very easily be done by first removing the armature, as explained before, and then disconnect the field leads. If all of the field coils are to be removed it will not be necessary to separate the connecting wires between the coils. It will be noted that there are two connectors, one in each of the out going field leads, which should be disconnected in case all coils are to be removed. One male and

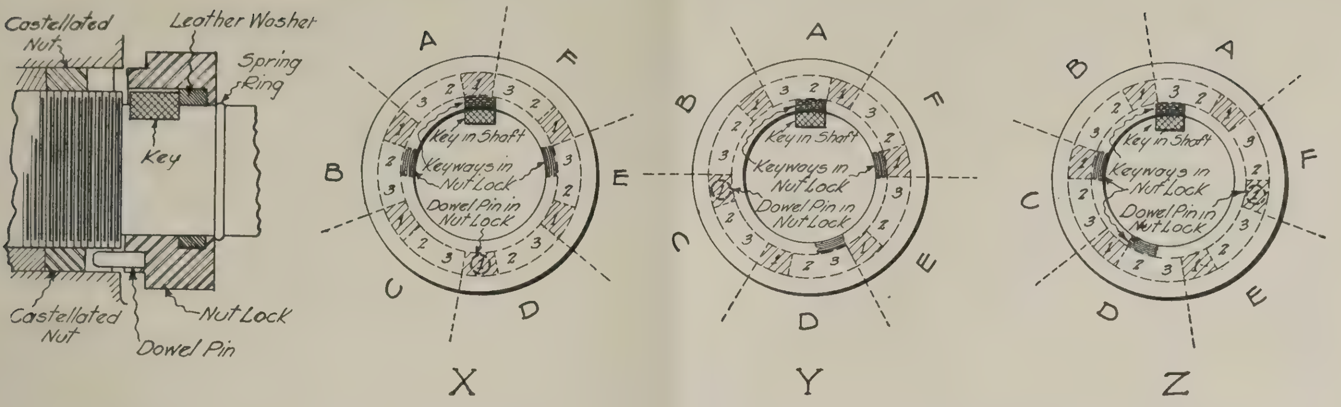


Fig. 219. Diagrams Illustrating the Method of Applying the Castellated Armature Nut.. The Nut Lock Has 3 Keyways to Fit Over Shaft Key in Any One of Three Positions, and This Also Carries a Dowel Pin Which Slips Into a Castellation of the Armature Nut and Prevents It from Turning and Working Loose.

one female connector is placed on the field coil side and one female and one male connector on the external circuit side of the connection so that in reconnecting the field coils into circuit it will be impossible to connect them so as to give wrong polarity.

The two large cap screws on the outside of the generator frame which hold each pole piece in place should then be unscrewed. This allows the pole pieces and field coil to be removed from the frame. The field coil is then easily slipped from the pole pieces.

In replacing field coils, it will be noticed that all coils are wound with both leads extending beyond one end of the coil, thus forming a closed hair-pin. In applying, they are placed in the magnet frame so that the leads of coils extend alternatively toward the commutator and pulley ends, the leads of the lower right hand coil, when facing the commutator end, extending toward the commutator end. Adjacent leads are then connected, except the two on the right hand side, which are brought out, the lead of the upper coil being equipped with a female connector and the lead of the lower coil with a male connector.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Quick Acting Foot Switch.

In the May issue of the RAILWAY ELECTRICAL ENGINEER a short article was given showing view of the large double lift bascule bridge at the Soo. A special quick brake foot switch designed by the writer for use in connection with this bridge may be of interest. Both leaves of the bridge are operated, each with two 40 h. p. Westinghouse type "K" motors mechanically connected together and each motor is equipped with a spring brake solenoid release and both solenoids are in series and are connected on the first notch of the operating controller, as shown in Fig. 1.

In closing the bridge both sides are, of course, lowered and as they approach the zone of interference the power for the North Leaf is automatically cut off, while the South Leaf engages the jaws of the North, at which time the operator with a special foot switch is able to obtain current independent of the operating controller to release the motor brakes on the North leaf, at which time both leaves are brought to a closed position by the action of the motors operating the South leaf. These foot switches originally installed by builders of the bridge were of very primitive design consisting simply of a round wooden drum mounted in two bearings with a counterweight attached which served to open the circuit between the contacts mounted on the drum when the foot pressure was released.

The actual current in these cylinders is but 5 amperes, but the inductive effect is so great that when the circuit is broken an arc about 4 in. long forms and this actually started to burn the wooden drum. In order to solve the difficulty an entirely new type of switch was designed by the writer as shown in the accompanying illustration, Fig. 2. One of these switches was made right handed and one left hand-

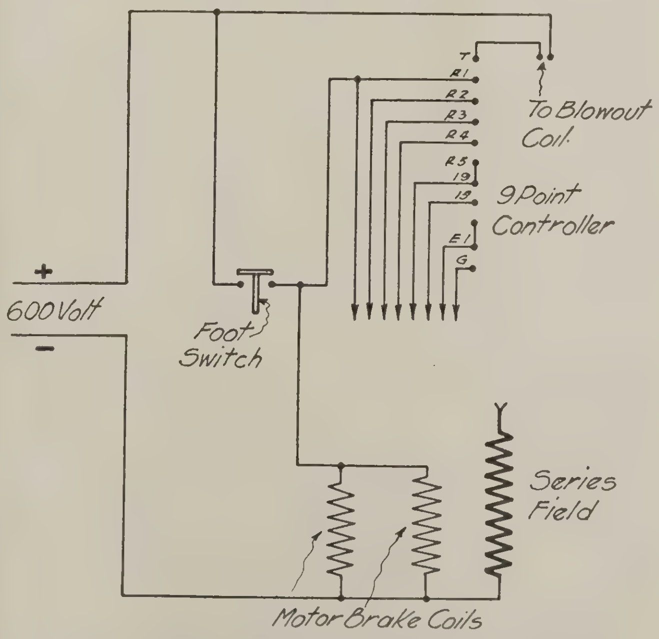


Fig. 1. Wiring Connections of the Quick Acting Switch.

ed to replace the wooden drum type switches. These new switches have been in service since navigation was opened this spring and have proved to be most satisfactory.

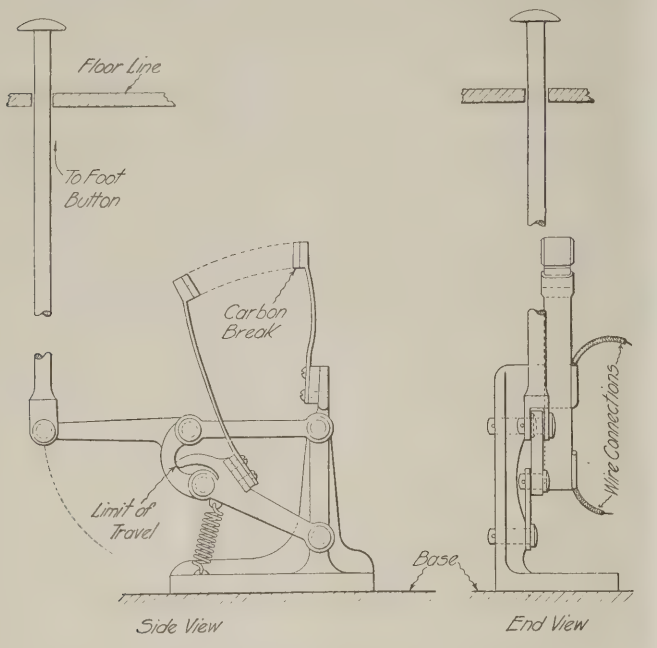


Fig. 2. Mechanical Details of the Quick Acting Switch.

It will be noted from the diagram, Fig. 2, that the link mechanism of the switches produce a quick acting break switch. The contact points of charge being carbon blocks are not injured by the flash of the arc on opening the circuit.

J. G. Koppel, Elec. Supt. of Bridges.

Equipping Old Generators with Ball Bearings.

When ball bearings were first applied to car lighting generators, we realized that the advantages of low maintenance costs and greater reliability of the ball bearings would be equally desirable in existing equipment as in new equipment, and accordingly, at an early date, we endeavored to apply these bearings to some of our old machines.

As is well known, the pulley end bearing gives much more trouble than the commutator end bearing does in generators equipped with plain sleeve bearings. On account of the fact that the belt pull comes directly on this bearing. In fact, a good bronze bearing on the commutator end of the machine will last two years or more if properly taken care of and the commutator end of the shaft lasts from 2 to 4 years. The pulley end bearing, however, is quite another story.

We have adopted the scheme of making a new pulley end housing and applying a ball bearing to the pulley end of our old Bliss and Moskowitz machines as the bearings require renewing, but the commutator end bearing is not disturbed. This method of remodeling has been tried out extensively and more than 100 generators are already equipped in this manner.

The cost of making this change is small, since the change is not made unless the shaft and bearing at the pulley end are both worn out. It costs about 75c more to make a ball bearing shaft than it does to make a plain bearing shaft. The special head for the pulley end housing of the generator when made up in the shop costs about $5.25 and to this total figure of $6.00, the cost of the ball bearing would have to be added and from this total cost, the price of the pulley end bronze bearing should be deducted.

In regard to the saving in maintenance costs by using a ball bearing at the pulley end; it has been our experience that the cost of bronze bearing replacements average about $4.25 per year and the wear on a bronze bearing shaft costs about $4.00 per year; these figures being exclusive of the labor cost for changing the bearing and shaft and also exclusive of the additional inspection and oiling required by a plain bearing.

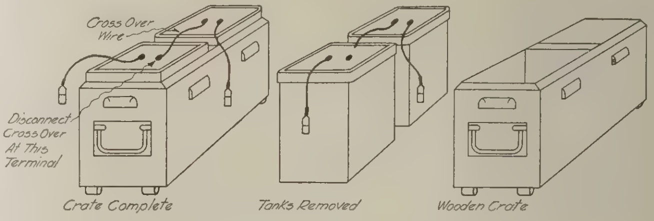
Many of the generators remodeled in this manner have been in service for more than two years, using self-aligning bearings and no bearing trouble whatever has been experienced. As to the probable life of ball bearings it has been my experience that they are in strictly first-class condition after two years of service and I am very firm in my belief that the cost of remodeling an old car lighting generator and installing a ball bearing at the pulley end, will be saved in the first two years of use of the ball bearing.

It is a great deal easier to tear down a machine for repairing the brush rig when it is equipped with a bronze bearing on the commutator than with a ball bearing. Therefore in some types of machines, in which the brush rig requires considerable inspection and repair, it is advisable to have a bronze bearing on the commutator end. In remodeling the dynamos, the ball bearings should be of the self-aligning type to allow for any inaccuracy in workmanship in making the change.

S. W. Everett, Electrical Engineer, Santa Fe.

Renewing Battery Crate on Car Lighting Batteries.

It is sometimes necessary to make a quick replacement of a battery crate without dismantling the whole battery. This can be done as follows: Remove the cross over wires, break the wooden crate from around the tanks, pour the proper mixture of sealing compound and paraffine wax into the compartments of a new wooden crate, then place the cells complete in each compartment, replace the cross over wires and the job is finished.



Process of Renewing Battery Crate.

This obviates the delay caused by removing the elements in the lead lining and forcing the tank into the wooden compartment and there is no danger of injuring the tank by hammering on it with a wooden strip. The weight of the elements in the tank forces it into place and distributes the sealing compound between the tank and the wooden crate.

Charles W. T. Stuart, Penn R. R.

Argentine Railway Extension.

A new 71-mile railroad is to be constructed between Alvear to San Rafael, Argentina. The region traversed is said to be well irrigated and under intense cultivation. The system adopted is that of the so-called secondary railway with a 2.46 ft. gage. Steam traction will be used at first, but it is planned to electrify later. Work will be commenced in about six months.

General News Section

Mr. E. S. M. Macnab.

The many car lighting friends of Mr. E. S. M. Macnab, both in this country, Canada and across the water, will be pleased to learn of his recent appointment as engineer of electric car lighting of the Canadian Pacific R. R.

Mr. Macnab was born in Dublin, Ireland, in 1882, received a technical training at the Royal College of Science, Dublin, and also at the Dublin Technical Institute. In 1900 he entered the service of the Midland Great Western Ry. Co. of Ireland as a special apprentice and in 1905 was appointed general foreman of the passenger car shops, having charge of electric car lighting and he held this position until 1908. He then was in the employ of a supply house in Ireland previous to entering the service of the Canadian Pacific R. R. in 1909 as electrician. In 1910 he was appointed electrical foreman of the car department at the Angus shops of the Canadian Pacific R. R. In 1911 he was appointed car lighting inspector and in June, 1915, engineer of electric car lighting, which position he now holds.

E. S. M. Macnab.

Car Lighting Notes.

Mr. L. D. Smith, formerly battery foreman at the Chicago yards of the Rock Island, has been appointed foreman in charge of car lighting at the Kansas City Terminal, Kansas City, Mo.

Mr. H. A. Copell has been appointed electrical foreman of the New York, New Haven & Hartford R. R., located at Boston.

H. H. Halm has resigned his position as engineer of electrical operation with the Safety Car Heating and Lighting Co. to enter the automobile truck business. After September 1st he will be located with the Croce Automobile Manufacturing Co., at Asbury Park, N. J.

In Charge of Southwestern Territory.

The Willard Storage Battery Company have recently appointed Mr. E. L. Myers to take entire charge of their railway sales and service in the Southwest.

His broad experience in electrical work, and a thorough knowledge of railroad conditions in the section named should make Mr. Myers fully qualified for his new duties.

Although born in Illinois, Mr. Myers has been west of the big river so many years that he seems to belong there. Beginning back in 1888 as division lineman and construction foreman for the Western Union Telegraph Company and the Santa Fe R. R. Co. in California, he went to El Paso, Texas, in 1899, and worked for the telephone and electric light companies. From 1901 to 1909 he was construction foreman and general foreman for the Mexican Central Ry. Co. From 1909 to 1913 he was chief electrician in charge of all electrical work on the entire system of the National Railways of Mexico. The unsettled conditions in that country brought him back to the United States, where he was with the C. G. W. R. R. Co. only a few months before the Willard Company recognized in him a valuable man for the storage battery field.

Saurman Made Southeastern Manager.

Mr. A. B. Saurman, who for the past twelve years has been Pacific Coast manager for the Standard Underground Cable Company, has been appointed southeastern manager of the company, succeeding the late Mr. E. T. Hughes. Since 1893 he has been associated with the company, working up through the construction department, into the eastern sales department. In 1900 he organized and was made manager of the northwestern sales department, where he remained for two years, when he was transferred to San Francisco. This makes over twenty-one years that he has been actively associated with the company.

Mr. J. P. Bell will succeed Mr. Saurman as Pacific Coast manager, and who, like Mr. Saurman, owes his advancement to merit, rather than favor. Mr. R. M. Hirst and Mr. Kershner will continue to be associated with Mr. Saurman, as formerly with the late Mr. Hughes.

Mr. W. P. Cochran, formerly branch manager of the Westinghouse Electric & Mfg. Company at Baltimore, has been appointed assistant district manager of the Philadelphia district, including Baltimore, his headquarters being in former city. Mr. M. H. Jones, assistant to manager, will have charge of the Baltimore branch office.

Edison Storage Battery Co. Notes.

Mr. Charles E. Poyer has been appointed Assistant General Sales Manager of the Edison Storage Battery Co. Mr. Poyer has been with the Edison interests for about four years, having served first on the personal engineering staff of Mr. Edison in the development of special application of the alkaline battery, and later as Assistant Advertising Manager. He has been Manager of the House Lighting Dept.

U. S. L. & H. Co. Reorganized.

On July 1st the receivership of the U. S. Light & Heating Co. was lifted and the property passed into the hands of the new company at a recent meeting of the board of directors and officers of the old company were re-elected, which to those interested in the welfare of the company is taken as the greatest assurance that the company will be managed in a conservative and businesslike manner.

With the Manufacturers

Ampere Hour Meter Applied to Gould and Safety Equipments.

It will be recalled that in previous descriptions of the use of the ampere hour meter for controlling battery charge in axle types, the meter simply controls the operation of an auxiliary relay. On the Illinois Central R. R., however, numerous equipment of both the Gould Simplex and the safety type "F" designs are controlled by an ampere hour meter without any auxiliary relay whatever, the ampere hour meter simply short circuiting a segment of resistance in series with the modifying coil so as to decrease the resistance of the voltage modifying coil circuit about 12%, thereby making the coil operate so as to reduce the charging potential to 36 volts when the meter shows a full state of charge. Since the current through the modifying coil is only approximately one ampere, and since the voltage across the meter contact is never more than 3 or 4 volts, the meter will undoubtedly give satisfactory service where operated in this manner. In fact, some equipments have been so operated for over a year.

The Sangamo Electric Company, manufacturers of the ampere hour meter, advise that they are now building meters with a more substantial quick acting contact capable of handling considerable larger current at much higher voltage than is required in this service. They also advise that ampere hour meters can be furnished equipped with a thermo couple, making the meters very accurate on light load, in fact, having a constant creep to make up for battery losses standing on open circuit.

Self-Starting Alternating Current Motors.

Motor-driven tools in the shop must be controlled as simply as possible. The workman, the motor, and the machine can be fully protected only by the use of motors that require a single operation to start, viz. "Close the switch." This control can be obtained by the use of complicated automatic motor starters, but the Wagner Electric Manufacturing Company, of St. Louis, Mo., has found a simpler way. They have included a simple starting mechanism in the motor itself, which operates by centrifugal force. It is, therefore, powerful and sure to operate at the required speed.

The single-phase motor starts as a repulsion motor, with starting torque several times full load torque. It will, therefore, pull full load up to normal speed, and without drawing an excessive current. This is important, particularly in an isolated plant, which is furnishing light as well as power.

When the motor has attained nearly normal full load speed the centrifugal mechanism operates, releasing the brushes and interconnecting the armature coils. The motor then operates as a single-phase induction motor. This is the only type of single-phase motor that will start full load without clutch or any other intermediary device. Furthermore, as the centrifugal mechanism always changes from starting to running connection at the same speed, there is no possibility of a premature throwover with resulting heavy current draw, as when the starting is left to the workman who may be in a hurry.

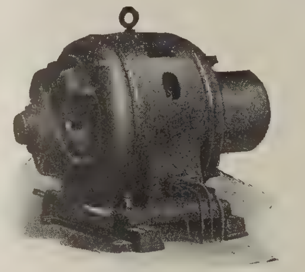


Fig. 1. General Appearance of a Medium Sized Motor.

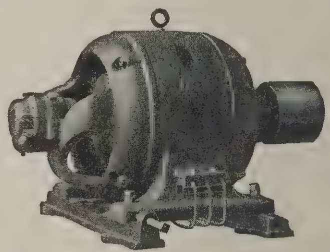


Fig. 3. Large Sized Motor.

Some central station companies require the starting current of motors to be not more than one and one-half times full load current. When the current to Wagner single-phase motors is limited to this value they will develop full load torque.

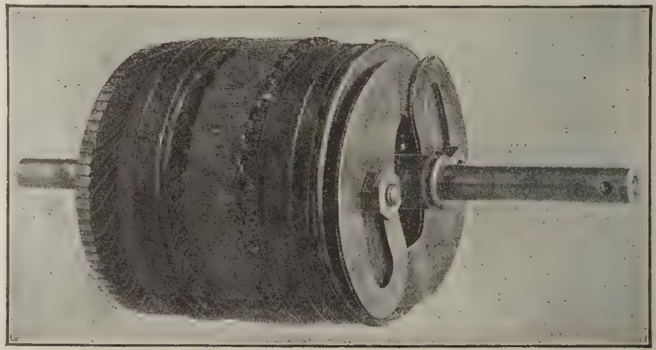


Fig. 2. Appearance of Armature Used in Small Machine.

These motors are adapted to any machine that operates at constant speed. The value of starting torque may be varied within wide limits to take care of different operating conditions, such as blower and centrifugal pumps on the one hand, and line shafting, bulldozers, etc., that require large starting torque, on the other.

These motors are made in sizes from ¼ to 60 horsepower. Figure No. 1 shows the general appearance of a medium sized motor, complete with rails and pulley.

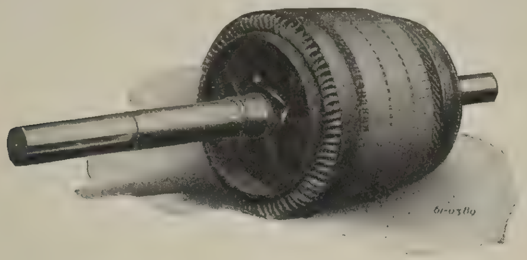


Fig. 4. Rotor of Large Sized Motor.

The frame is of cast iron, with the feet of the motor cast integral with it. The end bells are single castings, which insure concentricity of bearings and frame, and keep the bearings in alignment. The bearings are of phosphor bronze, and in the largest sizes are split.

Figure No. 2 illustrates the appearance of the armature of a medium size motor. The governor mechanism weights are clearly shown on the end.

The polyphase self-starting motor is in all mechanical respects identical with the single-phase motor, except that the brushes and brush mechanism of the single-phase motor are not required.

The motor starts with characteristics similar to the slip ring type of polyphase motor. It develops at starting much more torque for the same current than does the squirrel cage type motor. At about 80% normal full load speed the centrifugal governor mechanism changes the armature connection from the high torque starting to the normal running torque connection. This is also a constant speed motor, but is adaptable to a large variety of uses.

Figure 3 illustrates the external appearance of a large size motor, and figure 4 the rotor. Note the governor mechanism inside the armature.

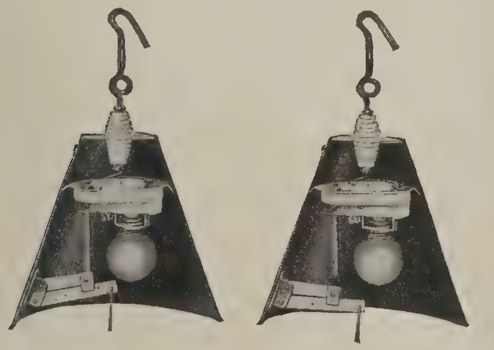


Fig. 1. Potential Indicator Consisting of an Electrostatic Glower and a Metallic Condenser Hood.

Electrostatic Potential and Synchronism Indicators.

Electrostatic vacuum glowers are now being used to indicate the presence of potential on high voltage a-c. circuits, and to determine when such circuits are in synchronism and may be thrown together.

For indicating potential, two appliances as shown in Figs. 1 and 2 have been developed by the General Electric Company. The first consists of an electrostatic glower, a metallic condenser hood, a switch for cutting the glower in and out of circuit, and a hook for suspending the indicator from the line and leading current to the glower. One terminal of the glower is connected to a spark gap and then to the lower end of the suspension hook; the other terminal, to the condenser hood. The loop in the suspension hook enables the indicator to be hung over the line by means of the ordinary type of switch hook used for operating disconnecting lever switches.

The indicator switch when closed provides a low resistance path between the line and the hood, and cuts the glower out of circuit. When the switch is open, the glower is connected between the line and hood through the spark gap, and will light up if there is potential on the line at least equal to the tension between the line and ground on a three-phase system carrying 15,000 volts. This indicator is used for indoor and outdoor service, and, as a rule, hangs on the line continually, but, of course, can be moved about as desired. Usually a grounded wire is connected to the switch string sufficiently close to the hood to be out of reach of the operator.

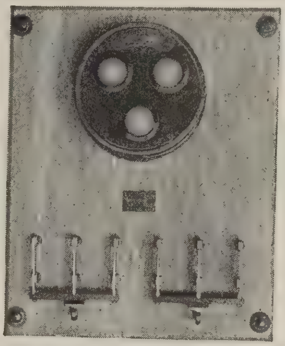


Fig. 3. Electrostatic Synchronizer Operating on a Minimum Voltage of 13,200 Volts.

The second form of indicator, shown in Fig. 2, is essentially the same as just described, except that no switch is provided and the hood is attached to a long wood rod equipped with a ground cone for connecting a wire between the rod and ground. The upper terminus of the lead running down to the spark gap inside the hood is connected to another lead going to the top of the pole to a metal pin, which is held against the line to determine whether the line is alive. This indicator is, because of its easy portability, most suitable when the indication of potential may be desired on a number of lines.

In using an eelctrostatic indicator, one should always bear in mind the fact that, although the lighting of the glower gives a positive assurance of voltage on the line, the lack of glow does not by any means prove the line to be dead, because the bulb may be broken, the leads disengaged, the potential too low, etc.

The usual method of indicating when a-c. lines or machines may be thrown together is by the use of a synchronism indicator and synchronizing lamps, or by

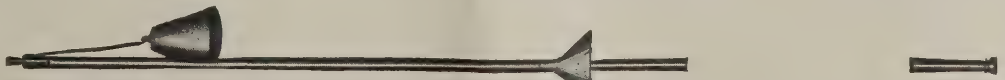


Fig. 2. Potential Indicator Hook Attached to Long Wooden Rod Attached to Ground Cone.

ORIGINATORS OF AUTOMATIC SWITCHLESS TELEPHONES
DE VEAU
TELEPHONES

OKONITE
TRADE MARK REG. U.S. PAT. OFFICE
INSULATED WIRES AND CABLES

BERYLITE
TRADE MARK
GLASSWARE

ELECTRICAL

For All Classes of

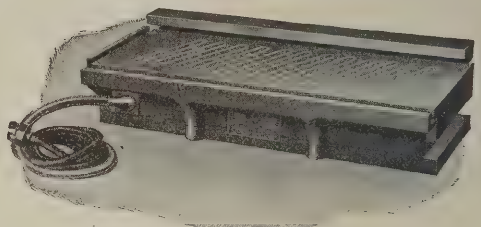
Alexalites

may be used
with any
size Type "C"
Mazda lamp

The very intensity of light from the Type C Mazdas makes indirect lighting more necessary now than ever. And they increase the Alexalites margin of practicability as well as desirability.

Ask us why.

D. & W.
Magnetic Chucks



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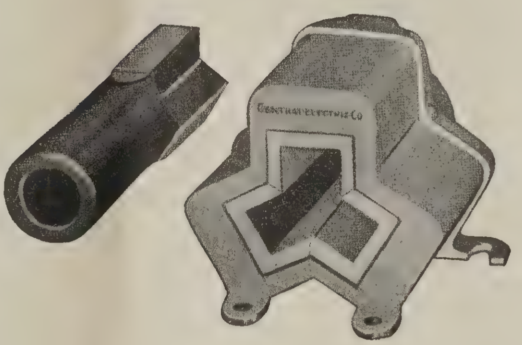

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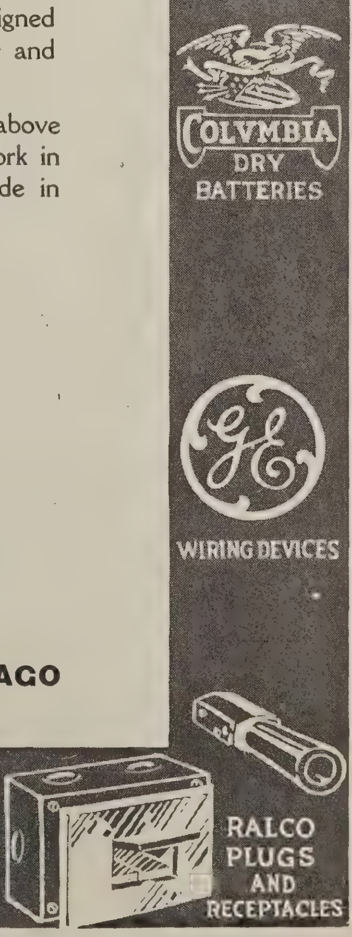

RALCO
PLUGS
AND
RECEPTACLES

either the indicator or lamps separately, employing also as a rule the potential transformers that are used in conjunction with the meters or instruments. This arrangement is entirely satisfactory; but when it is desired to connect systems together where transformers are not needed for indicating or measuring purposes, the equipment is comparatively expensive. The higher the voltage, the more does this apply.

The electrostatic synchronizer of the General Electric Company, shown in Fig. 3, requires for operation, however, only the charging current of the line. It consists of a few simple and inexpensive parts, and can be used to considerable advantage in main stations where current is metered on the low side, in switching stations, line junction stations and some substations.

Three electrostatic glowers, mounted in a case, which resembles that used for a round pattern switchboard instrument, are used for each synchronizer. The glowers are connected to the line through condensers consisting of suspension insulators, the insulating value of which is at least equal to that used for insulating the line.

To use the synchronizer, the terminals of one of the glowers are connected through the insulators to the leads of the same phase of running and incoming lines. The other glowers are each connected across dissimilar phases of the remaining leads of the running and incoming lines.

When the lines are not in synchronism, the glowers will indicate the relative frequency of the lines in the same manner as the usual synchronizing lamps. When in synchronism, the rotating effect will disappear, the glower connected to the corresponding lines will be dark and the other two will show about one-half brilliancy. The minimum voltage for operation is 13,200, and the maximum depends only on the use of the proper number of insulators.

The synchronism indicator can be used as a ground detector by connecting one terminal of each glower to the ground and the other terminals to the line. A lighted glower will indicate that the line is at potential above ground; i. e., not grounded.

The Economical and Efficient Electric Hammer.

The line of Western Electric hammers that is being marketed by the Western Electric Company can be operated at a power cost that is practically negligible, ranging from 2c to 5c an hour and depending upon the size of hammer used. The equipment investment is small, only the cost of the tool having to be considered.

A man with an electric hammer may be expected to do about as much work as six men working by hand. This is easily explained by the fact that a man with a hammer strikes from 50 to 80 blows a minute while the electric tools strike from 1400 to 4000.

These electric hammers have long since passed the experimental stage and are being used successfully by companies installing switchboards, pneumatic tube systems, piping, railings, sprinkler systems, fire escapes, fire doors, etc. One general contractor tells of the great saving through the use of these tools in taking out the mortar between bricks for repointing, another of using them in breaking up old engine bed foundations and sidewalks. Paint mills use them for dressing mill stones, ice plants and central stations for chipping scale off condenser tubes. In fact, wherever a rapid succession of blows makes for saving, these electric hammers are being used successfully.

An attractive booklet giving further details may be obtained by writing to the Western Electric Company.

"Results of Electrification."

Circular 1505, is the latest publication brought out by the Westinghouse Electric & Manufacturing Company. Results obtained by electrification on some of the important steam railways of the world are included in this circular, giving information of interest and value to Steam Railroad Operators on Electrification Work.

Contained in this publication are well illustrated descriptions of the Norfolk & Western, Pennsylvania, New York, New Haven & Hartford and other electrifications installed by the Westinghouse Company.

The Westinghouse Electric & Mfg. Company has recently issued the first number of Westinghouse Electrification Data, a periodical to chronicle the latest advances in the field of heavy traction. The present number contains a discussion of electric locomotive characteristics, some interesting figures on the comparative maintenance costs of steam and electric locomotives, as well as data on the New York terminal electrification of the Pennsylvania Railroad.

Additions to Condulet Line.

Condulets, Bulletin No. 1000C is the title of a 6x9-inch, 32-page supplement to Condulets, Catalog No. 1000, that has just been issued by the Crouse-Hinds Company. This bulletin illustrates, describes and lists many new types and styles of Condulets and Condulet accessories, besides numerous additional sizes of older forms of Condulets. It is a book that should be exceedingly valuable to those who are at all interested in Conduit installations.

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The Vertical Lift Bridge

The vertical lift type of bridge seems to be coming into increased favor, for the completion of the two New York Central bridges over the Calumet river makes five of this type that are now in use in Chicago. Three of these bridges are owned and operated by the Penn. R. R., one of which was described in the March, 1915, issue of the RAILWAY ELECTRICAL ENGINEER and the two others with New York Central bridges are described in another part of this issue.

The four bridges over the Calumet river have a span of 250 ft., a vertical lift of 98 ft., and cross the river at an angle of about 50 degrees, and the bridges are each 150 ft.

The New York Central bridges have several marked improvements over former bridges of this type. By using nickel steel the weight of the span has been decreased to 700 tons as compared to 900 tons for the Pennsylvania bridges. Counterbalancing chains make the power demand more constant over the operating cycle. The wiring system has also been somewhat simplified by carrying the conductors in one cable.

One of the principal reasons why this type of bridge was used in preference to the bascule type is that it may easily be constructed on the skew, thus allowing a shorter bridge to be used than would be possible with the bascule type. In the case of the 19th St. Penn. lift bridge there is an added advantage in that there is a possibility that there will be a future grade elevation at this point. The vertical lift bridge can be used before, during and after elevation, it only being necessary to change the bridge approaches and the bridge seat as the work of elevation progresses.

The wind effect on a large bascule bridge is oftentimes very great, resulting in a large power consumption, often seriously damaging the operating motors, whereas the bridges in this installation are affected very little by the wind. The current consumption is also lower with the vertical lift bridge, especially with the use of counterbalancing chains. Although the vertical lift bridge is considerably cheaper in first cost than the bascule type, experience has not yet shown how the cost of maintenance will affect the economy of the installation.

In both the Pennsylvania and New York Central installations, one of the primary considerations has been safety and reliability. With the former object in view, the operations are interlocked so that it is impossible to raise the bridge until the track is blocked off. Dead man stops also prevent the bridge from overtraveling. To guard against breakdowns the control equipment is arranged in duplicate on the Penn. R. R. bridges so that both bridges can be operated from either controller house.

Duplicate sources of power are provided at the New York Central bridges. Normally the storage batteries are charged from a motor-generator set, but in case of the failure of this source a gas-engine-generator set furnishes the power. This consists of a four-cylinder gasoline engine flexibly connected to an electric generator.

Eighth Annual Convention A. R. E. E.

The Eighth Annual Convention of the Association of Railway Electrical Engineers will be held at the Hotel La Salle, Chicago, October 18th to 22nd. The convention proper will open Tuesday a. m. but an informal, get-acquainted reception and dance will be held as usual, Monday night.

Some excellent work is promised by the various committees and present indications are that the convention this year will surpass that of any previous year for actual results accomplished. The work of the committee on Standardization of Crane Motors has progressed sufficiently in tabulating data on existing equipment to clearly show that there has apparently been no attempt to standardize on this important branch of railroad shop equipment in the past. The committee is making a thorough investigation of the problem and will have some important recommendations to offer which should form a logical basis for a set of standard specifications for the motor equipment of traveling cranes of various capacities and operating speeds. It is expected that other committees will have similarly interesting reports.

An informal dinner dance to be held at 8:30 p. m. in the main ball room on the 19th floor of the Hotel La Salle, Thursday, October 21st, will close the entertainment features of the Convention—the final business meeting being held Friday morning.

Four Double Track Lift Bridges with Remote Control

Probably one of the most interesting draw bridge installations in the country is that at South Chicago, where the tracks of the Pennsylvania R. R. and New York Central Lines cross the Calumet river. Here the Pennsylvania R. R. have 2 large double track bridges, recently completed, and the New York Central Lines also have 2 double track bridges, on which the construction work has been completed, but which are not yet in operating condition.

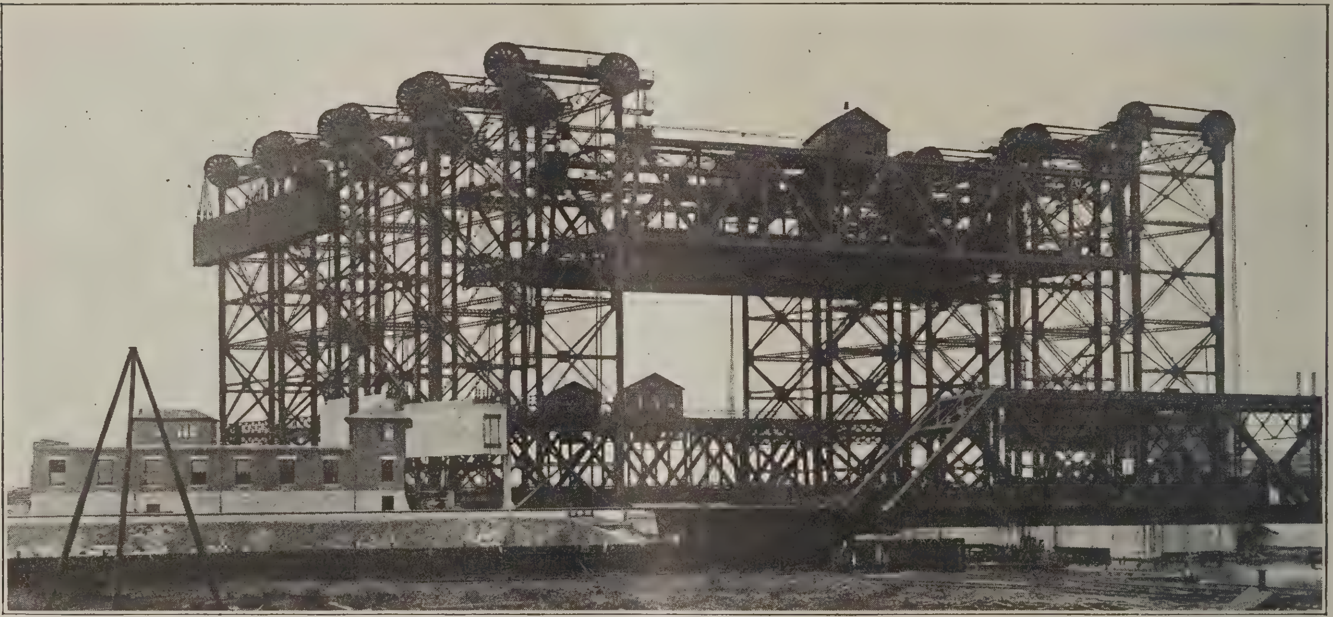


Fig. 1. Side View of the Four Double Track Vertical Lift Bridges, the Two of the Pennsylvania in the Background in the Down Position and the Two of the New York Central Lines in the Foreground, Shown Raised.

All of these 4 double track bridges are of the vertical lift type and are very similar in design, both as to mechanical construction and electrical operating features. In the detail of design, however, these two installations are somewhat different and it will be interesting and instructive to compare them. It is interesting to note the general favor with which this type of bridge seems to have recently come in preference to the bascule type, so commonly used heretofore. An earlier installation of this same type of bridge, installed over the Chicago river at 19th street, Chicago, was described in the March issue of the RAILWAY ELECTRICAL ENGINEER.

The right of way of the Pennsylvania R. R. and New York Central Lines crossing the Calumet river are adjacent and parallel, crossing the river at an angle of about 50 degrees, so that the bridges are all built on the skew, and being built so close together give very much the appearance of a single large bridge, as shown in Fig. 1. As mentioned above, there are four double track bridges at this point, the two of the New York Central Lines having a 210 ft. span and each weighing 700 tons, and the two of the Pennsylvania R. R. having a 210 ft. span and each weighing 900 tons. The New York Central Ry. bridges being constructed of nickel steel, makes the reduction in weight possible. Each double track bridge is operated independently and each is supported by 12 2 in. cables at each end of the bridge. These pass over great sheave wheels at the top of the steel towers, as shown in Fig. 1, and on the other side of the tower, support a great concrete block, which acts as a counterweight for one-half the bridge. These sheave wheels mounted on top of the towers have a diameter of 15 ft. so as not to cause any bending stresses in the supporting cables.

Operating Mechanism.

The vertical travel of each bridge is approximately 98 ft., and the towers supporting the bridges are each 150 ft. in height. The hoisting of each bridge is accomplished independently by motors and reduction gearing mounted in a machinery house on the top of each bridge. In general design the operating mechanism of both the Pennsylvania and New York Central installations are very similar. The reduction gearing for driving the four hoisting drums is located on either side of the motor shaft, as is shown in Fig. 6; this operates on a ratio of 38 to 1, that on the right side hoisting the north end of the bridge and that on the left side hoisting the south end, and being geared at the same ratio to the same motor shaft, insures that the bridge will always rise perfectly level, provided the hoisting cables do not slip, stretch or break. The two large driving axles, as shown at the extreme left and the extreme right of Fig. 6, have a 46 in. drum mounted at each end. On of the four hoisting cables located at the four corners of the bridge are wound around each of these four drums. These hoisting cables are fastened at the top and bottom of the tower and are coiled around the winding drum about ten times, being rigidly fastened thereto at the center coil. The bridge then pulls itself up by the four hoisting cables, very much as a spider climbs his web.

The two motors on each of the Pennsylvania bridges are of 225 h. p. capacity, while those of the New York Central are each of 100 h. p. capacity, although they all can carry a momentary overload of 200 per cent.

Method of Braking.

The method of controlling the operating speed of the bridge is, of course, a very important feature of such an installation. On account of the great weights involved, the ordinary solenoid brakes, employed in elevator installations, do not meet the requirements. When raising the bridge, the bridge is lifted by the up-haul cables and braking or slowing down the speed of the bridge must be accomplished by means of the down-haul cables. And similarly, the brige is lowered by means of the down-haul cable and the bridge speed is reduced or stopped by means of the up-haul cable. There is a certain amount of slack which always takes place in the cable which is not under tension and if the brakes are applied suddenly, as would be the case with a solenoid brake, this slack is taken out with a jerk and may seriously jar the bridge, or possibly break the supporting cables. Therefore it is necessary to apply the braking force gradually and in order to take care of this feature, a motor operated brake is installed on the Pennsylvania bridges and an air operated brake on the New York Central York Central mechanism is shown just to the right of center in front of the reduction gearing.

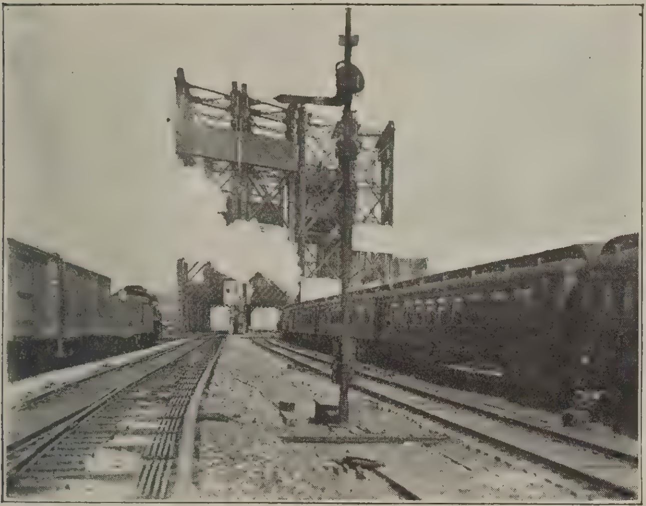


Fig. 2. End View of the Four Bridges, Showing 20th Century Limited Enroute.

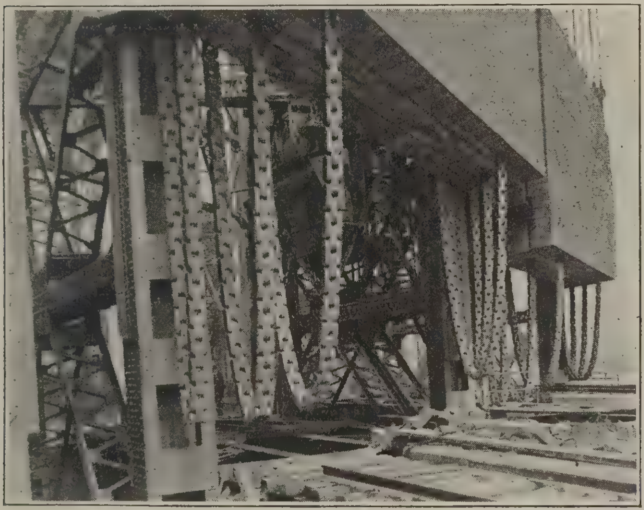


Fig. 3. Showing Concrete Block Counterweights and the Great Counterweight Chains Which Compensate for the Weight of the Supporting Cables, Keeping the Bridge in Perfect Balance at All Positions.

An emergency brake, with solenoid release, as shown in the foreground of Fig. 6, is installed at each of the bridges. This brake is applied directly on the motor shaft and is located midway between the two motors in each case. One of the air solenoids of the New motor shafts on both the New York Central and the Pennsylvania bridges. This brake prevents the motor shaft from turning when the bridge is at rest and is automatically set every time current is shut off the motors. Braking power is produced by the action of three steel springs at the top, acting through a toggle mechanism, strongly compressing two brake shoes on the brake wheel. The pressure of these springs is released by the action of the solenoid and this solenoid is connected in shunt with the hoisting motors so that as soon as current is passed through the motors this brake is automatically released, and as soon as current is shut off the motors this brake is set. It is adjusted, however, so that it is not of sufficient power to cause a serious jerking in the operating cables, the main braking being done by the air operated or the motor operated brake.

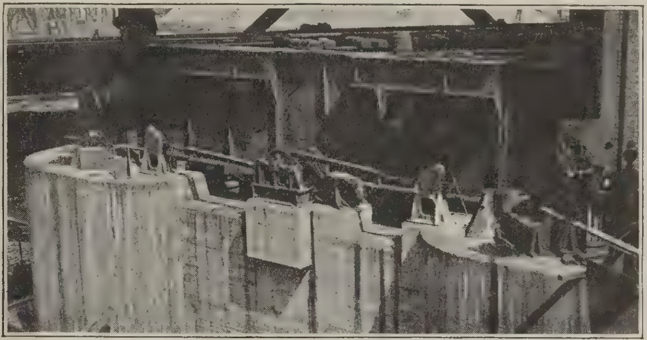


Fig. 4. Motor Operated Bridge Locks Which Hold the Bridge Firmly in Place. Motor Is Shown in the Center Covered with Canvas as Construction Work Is Not Yet Completed.

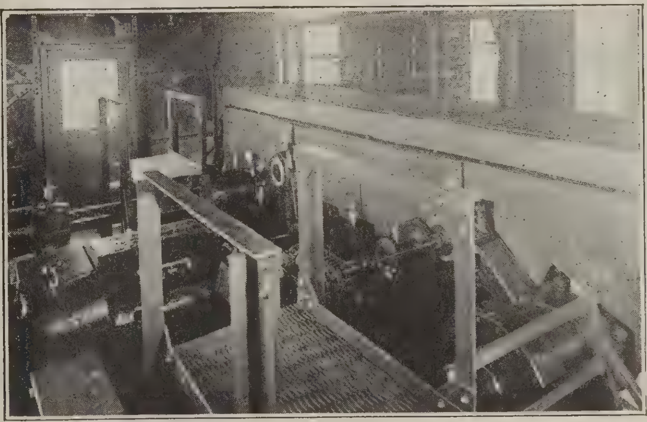


Fig. 5. Machinery House of One of the Pennsylvania Bridges, Showing One of the Motors and Solenoid Emergency Brake at the Left and Automatic Switching for Preventing Overtravel of Bridge Is Shown at the Right of Center.

There is an automatic air pump installed on each of the New York Central bridges which maintains a pressure of 80 lbs. in a storage tank of 20 cu. ft. capacity for operating the air brake. Two remote control magnetically operated valves are employed, one for applying the brakes, and one for releasing. An angle valve is placed in the supply line from the air tank and this is partly shut off so as to introduce a time element in the braking and preventing the air pressure in the brake cylinders from quickly coming up to full value. By careful manipulation of the application, hold and release of the air, the operator can gradually take up the slack in the cable, bring the bridge to a stop in the shortest time possible, and without injury to the bridge. In other words, he is able to feel the operation of the brakes very much the same as a locomotive engineer does.

On the Pennsylvania bridges the principle braking is by means of a motor operated brake. This consists of a 500 volt motor, wound for high torque, which is geared to a rack which operates the brake toggle mechanism, acting against the pull of two springs, to release the brake. There are three positions of the motor controller and three motor torques and braking powers to correspond with this: light, medium and heavy braking. The bridge operator using these three braking powers can very easily control the braking of the bridge with perfect satisfaction. Automatic brakes with a solenoid release are also installed at each end of the motor shaft, as on the New York Central bridges and in addition to this and an auxiliary hand brake is provided by means of which the operator, who is located directly below the machinery house can throw a lever and operate the motor operated brake by hand. When the bridge is at rest, both the solenoid release brakes and the air operated or motor operated brakes are set. Applying the air or operating the motor releases this brake and allows the motor shaft to turn. In both the Pennsylvania R. R. and New York Central installations the brake is operated by remote control from the operator's cabin.

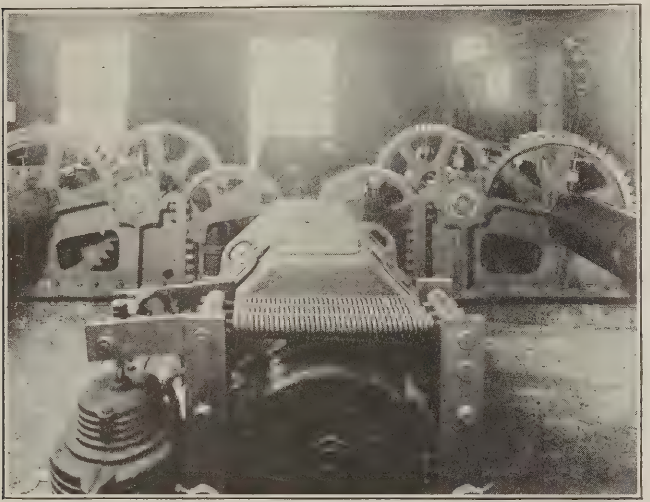


Fig. 6. Interior of the Machinery House on One of the New York Central Bridges, Showing Solenoid Operated Brake and One of the Motors in the Foreground. The Other Operating Motor Is Shown in the Background with a Double Set of Reduction Gearing on Either Side of Motor Shaft for Hoisting Either End of the Bridge. Ratio of Gear Reduction Is 38 to 1. Remote Control Panel Is Shown in the Background at the Upper Right Hand Corner.

Contact Systems.

The method of collecting current on the New York Central bridges is shown by Fig. 8. As may be seen, a double trolley serves to collect the current from both the trolley wires. There may be some difficulty in taking care of expansion and contraction of the trolley wire and in preventing sleet and ice from interfering with its action.

Current is collected on the Pennsylvania bridge by a sliding shoe in contact with a ribbon shaped contact wire which is about 1 in. wide and ¼ in. thick.

Bridge Control.

Remote control is employed for operating both the bridges of the Pennsylvania R. R. and the New York Central Lines. On the Pennsylvania bridges an operator's cabin is installed immediately below the machinery house on each bridge. However, a double control is installed in each operator's cabin, so that a single operator on either bridge can operate both bridges if necessary.

The control of the New York Central bridges is effected by a single operator, who is located in the control cabin about half way up and directly between the two bridge towers at the east side of the river.

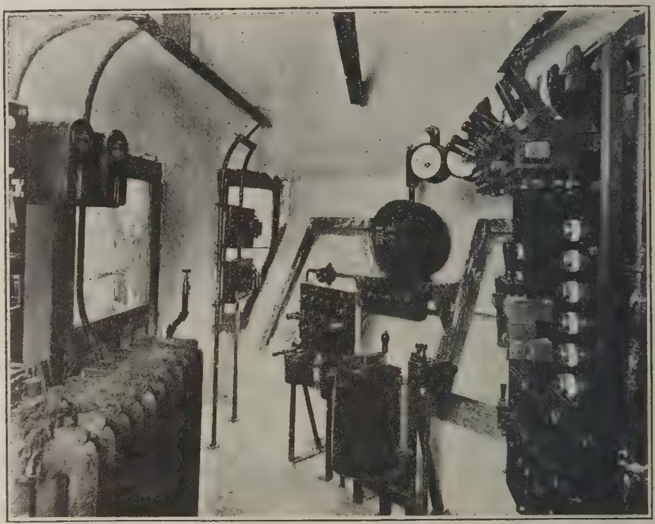


Fig. 7. Interior of the Operator's Cabin for Handling Both of the New York Central Bridges. Controllers Shown, However, Are for But One Bridge, at the Right Are Bridge Circuit Switches and Breakers; in the Center Is the Master Controller for Operating Bridge Motors; to the Right of This Is Shown the Controller for the Air Brake and to the Left Is Shown the Two Rail Lock Motor Controllers. Above These Are Emergency Switches for Throwing Off All Power on the Bridge. The Large Dial in the Background Indicates Height of the Bridge in Feet and Inches.

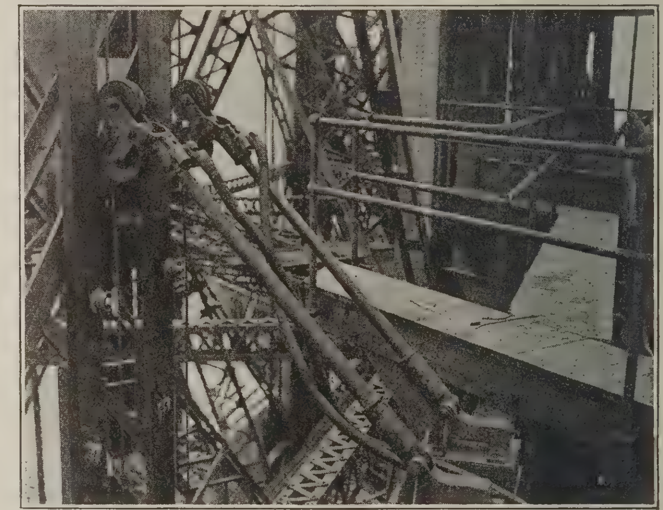


Fig. 8. Trolleys for Collection of Current, on the New York Central Bridges.

The interior of the operator's cabin of the New York Central bridges is clearly shown in Fig. 7. At the right are the switches and circuit breakers of the individual controlling circuits and in the center is shown the main controller drum with the air brake operating controller at the right and the two rail lock motor controllers at the left. At the extreme left is shown part of the board carrying switches of the ball signals for boats. At the left of Fig. 7 are also shown the two indicating signals which indicate when the signal tower man has set the blocks against the trains of either bridge so that it can operate. In the background at the center are the two automatic control panels for operating the rail lock motors of each bridge. These are equipped with dynamic braking so as to provide for a quick stop after the rail locks have been once withdrawn or inserted.

Large motor operated horns are mounted on all of the bridges to signal boatmen on the river. A small electric motor carrying a knobbed wheel on its shaft, which operates against the wearing button on the diaphragm of the horn, makes up the mechanism for this apparatus.

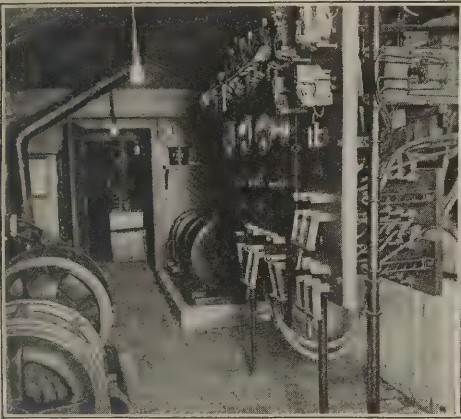


Fig. 9. Interior of the Pennsylvania Charging Station, Showing Two Motor Generator Charging Sets and 720-Ampere-Hour Battery in the Background.

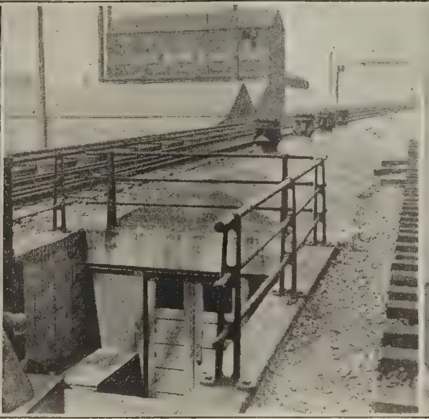


Fig. 10. Exterior of Pennsylvania Battery House, Which Is Located Directly Between the Two Bridge Tracks.

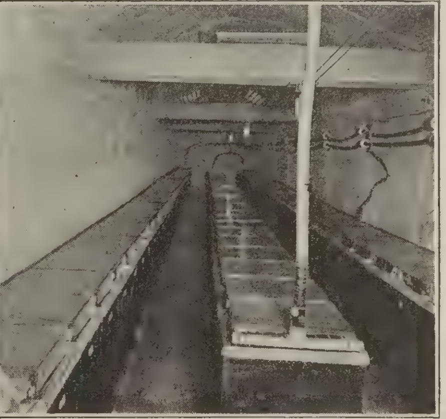


Fig. 11. Interior of Battery Room, Pennsylvania Plant.

There is a certain definite procedure which must be followed in raising any of the four bridges; this is as follows: 1st, the signal tower man must have all signals of tracks crossing that bridge set at danger. This is indicated in the operator's cabin by a white indicator light on the Pennsylvania bridges and by a signal relay on the New York Central bridges. Power is then available for operating the rail lock motors, but not until the rail locks have been completely withdrawn is power available for operating the master controller of the hoisting motors. This feature is provided by contacts at each of the rail locks, which are connected in series with the master controller. When the rail locks have been withdrawn this is indicated by two white lights on the indicator board, one for each rail lock, and the operator can then raise the bridge by manipulating the master controller. This controller does not carry the main current for the hoisting motors, but simply operates relays on the remote control panel in the machinery house, the resistance grids of which are shown in the background at the upper right hand corner of Figs. 5 and 6.

As the bridge nears the upper or lower limit of operation the speed is automatically diminished and when within 10 ft. of the limit the master control circuit is completely opened and the motors stopped. The control circuit can be re-established, however, by the operator pressing a button shown above the small controller switchboard in the center of Fig. 7.

An air cylinder cushioning device is mounted at each of the four corners of both New York Central bridges. When the bridge gets to within about 2 ft. of the bridge seat these air cylinder pistons strike and cause the bridge to gradually settle into place. No such devise is provided on the Pennsylvania R. R. bridges.

Indication of Bridge Height.

A circular disc indicator shown in the background of Fig. 7 in the operator's cabin indicates the exact height of the bridge to an accuracy of ⅛ in. The traffic requirements require that the bridge should be seated to within an accuracy of ⅛ in. and accordingly both the bridge control and height indicator must be adjusted correspondingly accurate. In seating the bridge it is usually necessary to force it down with the down-haul cables and it must be brought to within ⅛ in. of the proper position before the rail locks can be inserted.

In the Pennsylvania bridges this indicator is geared to one of the hoisting drums, since the operator's cabin is located immediately below the machinery house. In the New York Central bridges, however, where the indicator is mounted in the operator's cabin in the bridge tower, a small sheave wheel, mounted on the main supporting sheaves on the top of the tower drives a cable which drives the elevation indicator.

Down position on Pennsylvania bridges is indicated by means of contact switches on each end of spans which strike projections on the towers and give positive indication that bridge is seated and rails can be safely locked.

The bridges of the New York Central are forced onto their seats by means of large motor operated wedges. Fig. 4 shows the mechanism on the pier of one of the bridges. A gear on the motor operates a rack on the wedges, through a gear train, so that when the bridge has been lowered to within a few inches of its seating position, power can be applied to the motor and these wedges will pass over a shoulder on the foot of the bridge forcing it tightly into place and locking it in that position.

Safety Stop.

An automatic stop is provided for both the up and down travel of the bridge so that when the bridge gets to within 10 ft. of either upper or lower limits, the circuit of the master controller is opened, thereby stopping the motors and automatically applying the air or motor operated brake and solenoid brakes. The circuit of the master controller can be re-established by pressing the button shown above the rail lock motor panel in the center of Fig. 7, so that the operator can make use of the bridge motors in forcing the bridge down to proper seating and holding it in position until the rail locks are inserted.

Emergency Features.

Every possible means has been employed to guard against trouble in the case of an emergency. Automatic stop limits for both up and down travel are employed, as described above; in raising the bridge the circuit of the master controller is not complete until all rail locks have been entirely withdrawn and the bridge is free to rise; all brakes are automatically set as soon as power is shut off so that in case of an accidental breaking of the circuit the bridge would quickly come to a stop.

In the Pennsylvania R. R. bridges a duplicate remote control equipment is installed in each bridge so that either of the bridges may be operated from the other in case of a man failure; an emergency cable is installed between the two charging stations so that power from the station of one railroad can be supplied to that of the other and as all bridges are designed to operate at the same voltage, 220 volts, in emergency either of the batteries could be employed to operate any of the four bridges. A gas engine generator set is installed in the New York Central power house as an emergency generating set in case the a. c. power supply is interrupted.

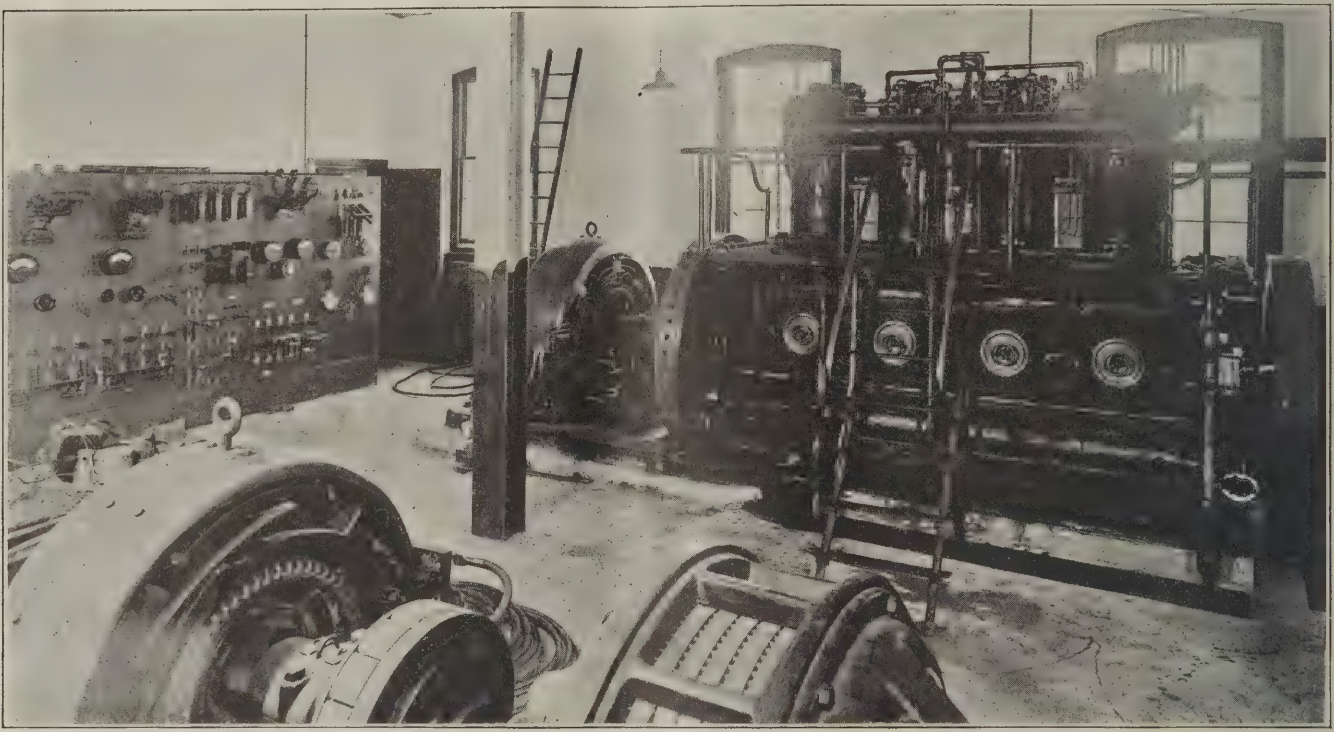


Fig. 12. Interior of the Power House Operating the Two New York Central Bridges, Showing Motor Generator Set in the Foreground and a Four-Cylinder Gasoline Generator Set as Auxiliary, in the Background.

Power Supply.

Power for operating all the bridges is received from the transmission line of the Commonwealth Edison Co., at 2,300 volts. This is transformed down and passed through motor generator sets for charging a large storage battery in each installation. Power for operating the bridges is then taken direct from the storage battery and the battery takes care of the high peak load in starting the bridges and at the same time reduces the maximum demand to a minimum, which is an important factor in determining the price paid for power.

Pennsylvania Power Station.

Power for operating the two Pennsylvania bridges is supplied by a Gould battery of 720 ampere hour capacity at the 8 hour rate, 120 cells, giving a nominal operating voltage of 220 volts. The battery and the generating apparatus is installed in a battery house located underground between the tracks of the two bridges, as shown in Fig. 10. Two motor generator sets, each of 35 k. w. capacity, are installed for charging the storage batteries, as shown in Fig. 9. Starting and controlling panels with circuit breakers are shown at the left and battery room in the distance. The battery tanks are mounted on porcelain insulators to eliminate grounds, as shown in Fig. 11.

New York Central Power Station.

Power for operating the d. c. motors on the bridges is supplied by a Gould storage battery of 2,540 ampere hour capacity at the 8 hour. rate, and this is charged either by a motor generator set or a gas engine generator set, the latter being held in reserve as an auxiliary. The motor generator set, as shown in the foreground of Fig. 12, consists of a 200 h. p., 440 volt a. c. synchronous motor, to which is flexibly connected a 150 k. w. d. c. generator. The generator is equipped with interpoles and has a differential wound series

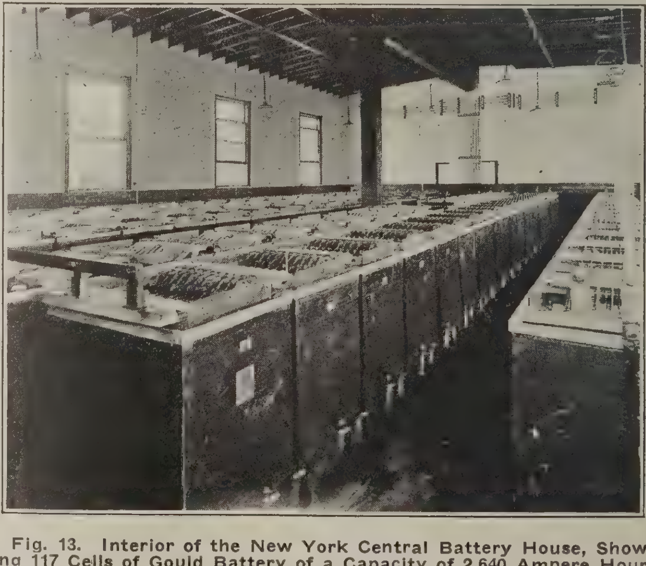


Fig. 13. Interior of the New York Central Battery House, Showing 117 Cells of Gould Battery of a Capacity of 2,640 Ampere Hours at the Eight-Hour Rate. Cells Are All Mounted on Porcelain Insulators with Oil Cups at the Top to Prevent Acid Grounds.

field, the purpose of which is to prevent the generator from assuming an undue portion of the load. In case the bridge is raised while the battery is being charged at a high voltage, as would occur near the end of charge, the amount of load assumed by the generator in such a case would, of course, depend upon the total load required. The generator is designed to carry a constant number of watts load so the generator in such a case would only carry a certain load, the additional power being taken from the batteries. The output of the generator is somewhat gauged by the setting of its field rheostat. This division of load averages approximately 90% on the battery and 10% on the generator for such operating conditions. The generator can deliver a charging voltage of from 220 volts to 320 volts, as desired.

Gas Engine Auxiliary Set.

A 200 h. p., 4 cylinder Bruce-MacBeth gas engine is installed as an auxiliary in case of failure of the a. c. power supply. This engine is direct connected through a flexible coupling to a 150 k. w., 250 volt, 250 r.p.m. generator equipped with interpoles and differentially wound series field to prevent overloading of the generator, as described above, and the characteristics of this generator are identical with those of the generator of the motor generator set so that the two can be operated in parallel if desired.

The steel work of the Pennsylvania bridges was installed by Kelley Atkinson Construction Co. and the electrical features designed by Geo. P. Nichols & Bro. of Chicago, the Cutler-Hammer apparatus being employed for all remote control equipment. The steel work of the New York Central bridges was erected by the Pennsylvania Steel Co. and the electrical equipment designed by their own staff, the remote control apparatus being supplied by the Electric Controller & Manufacturing Co.

Heavy Duty Contact Systems

In the July, 1915, issue of the RAILWAY ELECTRICAL ENGINEER, a number of papers were reviewed which were read at the 32nd Annual Convention of the American Institute of Electrical Engineers, held at Deer Lodge, June 29th to July 2nd. This session was devoted to the construction and operation of 3rd rail and overhead contact systems. Two papers which were not reviewed are given in part below:

Contact System of the Butte, Anaconda and Pacific Ry.

Mr. J. B. Cox, in the railway electrical engineering department of the General Electric Co. gave some of the results that have been obtained on the B. A. & P. R. R. Electrification in a paper with this title. The relatively large amount of energy required per local load unit made the adoption of the roller pantograph desirable. This type of collector is heavier than the slider pantograph and for that reason the trolley line should be made as flexible as possible.

The electrification of the B. A. & P. R. R. has been referred to frequently in these columns and the general features of the electrification have already been discussed.

The fact that approximately 60% of the tracks to be electrified consisted of yards and sidings with numerous switching and street crossings, with the added difficulty of protecting trespassers, made it advisable to use an overhead contact system. Traffic conditions demanded a locomotive unit with approximately 80 tons on the drivers, and motor capacity of approximately 2,400 h.p., which would mean 6,000, 3,000 or 2,500 amperes at 600, 1,200 or 1,500 volts respectively.

Estimates of total cost indicated that two direct current motors, operating in series from a 2,500 volt trolley, fed from two sub-stations, one at each end of the line, would yield most economical results. A double unit locomotive with capacity as described, would be required to collect from the 2,400 trolley, during acceleration, from 1,400 to 1,500 amperes, or 700 to 750 amperes per collector. Sliding pantographs will collect up to 200 amperes under similar conditions so the roller type of collector seemed more preferable.

A Shelby steel tube 5 ins. in diameter and 24 ins. long was used for making up the roller. Removable bearing housings of aluminum metal were fitted into each end and the completed roller revolved about a ⅝ in. steel shaft. The roller complete weighed 31 lbs. as against about 5 lbs. for the corresponding element of a sliding pantograph.

The demands of the overhead line construction for the satisfactory operation of the roller pantograph were that it should be even and flexible. The catenary type of construction seemed to meet these demands and to be the best system to use.

Redesign of Line Material.

It was found necessary to redesign all hangers, pull

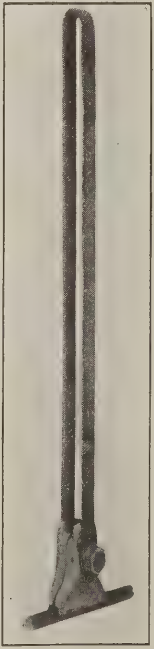


Fig. 1. Type C. H. Hanger.

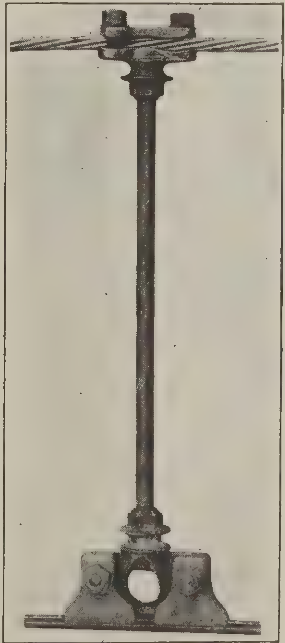


Fig. 2. Catinary Pull-Off.

offs and over line materials, which tended to add unevenly distributed weight or local stiffness to the trolley wire. Some of these new designs are shown in the accompanying figures. The large percentage of curve construction varying anywhere from a tangent to 22 deg. made it necessary to design a new pull off, by means of which the messenger and trolley wires are held in position by separate clamps from each of which run as individual pull off wire with a strut between, maintaining the pull parallel to the horizontal plane of the trolley wire, allowing free vertical movement independent of the messenger.

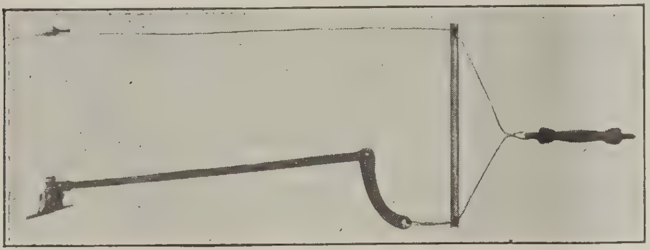


Fig. 3. Flexible Pull-Off for Pantagraph Collector.

Wood Poles Preferred.

The question as to the use of wood or steel poles for the supporting structure was not a difficult one owing to the general conditions and the nearness to the best of markets for good Idaho cedar poles, which may there be used more economically when compared with the cost of steel structure. One item of unusual character in connection with the trolley line construction was that required for about ¼ mile of track longside a slump pond from which the sediment is taken by means of the track line scraper bucket operated from a cable weight suspended between two traveling towers mounted on rails on either side of the pond. Empty cars were placed on the track in question for loading and the trolley would interfere. As it was desirable to use a standard locomotive for handling these cars, the brackets which supported the trolley in messenger wire were hinged to pole. By means of a hand operated windlass the brackets are swung upward, carrying the trolley from over the track and clear of the path of the bucket.

Insulation.

The question of insulation was not a serious one so it was merely a matter of choice between wood and porcelain insulators. As the climate in the locality was favorable the decision was made in favor of wood, which offered the greater general economy.

At switching points in ordinary trolley construction frogs are employed to make the trolley junction. For pantographs, deflectors are generally required to prevent the pantograph from raising the wire under which it is operating. When approaching such a junction toward a trailing switch, instead of this type of construction the trolley and messenger wires, which were intended to follow the switching track, were started several feet ahead of the switch from a convenient point for dead-ending and several inches above the horizontal plane of the through wires, and gradually brought down to that plane a short distance ahead of the switching point. At some points in the yards where parallel tracks leave the ladder track at close intervals, as many as six sets of wires are in the same horizontal plane and all the trolley wires make contact with the roller simultaneously, Fig. 4.

Air section insulation was used at all points where it was practical. Instead of inserting wooden insulators in the trolley line the ends of the wires of each section were made to overlap each other the length of a pole spacing, the two sets of wires being carried in approximately the same horizontal plain, but about 12 in. apart for a few feet in the middle for the span from which point the dead ends of the trolley wire were gradually carried above the path of the collector to its anchorage.

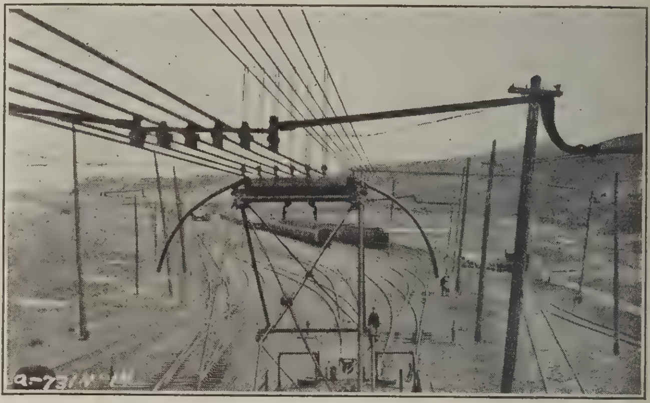


Fig. 4. Point in Yard Where Six Parallel Tracks Leave the Ladder Track at Close Intervals. Here Six Trolley Wires Are in Simultaneous Contact With Roller Collector.

This type of construction prevents hard spots in the line and there is less objection to subdividing the line into a large number of small sections and this over-

TABLE I.—COST OF DISTRIBUTION SYSTEM.

	Cost per item	Cost per mile
Labor installing	$129,027.56	$1417.89
Feeder copper	89,697.00	985 68
Work train service	64,268.31	706.25
Trolley wire	58,213.60	639.71
Cedar poles	27,739.21	304.83
Galvanized strand wire	26,807.47	294.59
Copper bonds	20,564.20	225.98
Hangers	7,596.27	83.48
Crosby clips	5,396.17	59.30
Wood strain insulators	5,385.22	59.18
Engineering and superintendence	5,289.30	58.12
Tools	3,811.30	41.88
Anchor rods	3,403.73	37.40
Sectionalizing switches	3,097.05	34.03
Injuries and damages .etc	3,036.56	33.37
Fitting up work cars	2,292.61	25.19
Steel and iron from stock	2,043.87	22.46
Lumber and timbers	2,013.61	22.13
Rental on work cars	1,716.50	18.86
Shop expenses	1,418.59	15.59
Lightning arresters	1,271.02	13.96
Paints and oils	901.32	9.90
Feeders and messenger insulators	842.15	9.25
Creosote and oil	637.00	7.00
Steel bond protectors	570.00	6.26
Splicing sleeves	294.00	3.23
Postage, car-fares, etc	238.62	2.62
Guards and signs	234.08	2.57
Wedge grips	130.01	1.43
Dynamite and fuses	121.36	1.33
Gasoline, solder, etc	100.46	1.10
Miscellaneous items	33,629.50	369.55
Total	$501,787.74	$5514.15

comes, to a great extent, the difficulties arising from contraction and expansion, due to changes in temperature.

At street railway crossings where the 2,400 volt line crosses a 600 volt line it was found necessary to use two wooden insulators is the high tension line, about 75 ft. apart. This was made necessarv on account of the operation of double unit locomotives with the trolley upon each. As the first insulator was usually about 100 ft. from the switch and the safety section was not energized until a member of the train crew ran ahead and freed a commutating switch located on a pole near the street crossing, which cut out the commutating section from the normal 600 volt connection and energized it with 2,400 volts current. Before the crews had learned from actual experience the damage that might result if a switch was not thrown until a locomotive passed under the first insulator, from the arcing that occurred when the roller left the live section of the insulator and ran into the dead section, the wood of the insulator was often carbonized until the insulation was finally insufficient and the insulator had to be replaced.

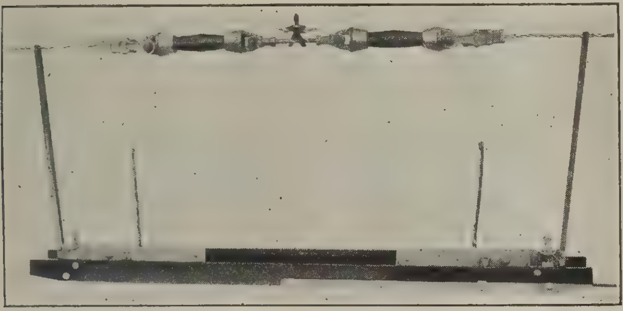


Fig. 5. Section Insulator for Pantagraph Collector Installed at Cross Span.

At most of the street crossing the use of a subswitching device was avoided by arranging with the street railway company to coast over the crossing. The electrical switches for controlling the crossings at these points were placed on poles near the watchman's tower and interlocked so as to make it impossible to energize the crossing with 2,400 volts current while the gates were closed.

The connections shown in Fig. — show the connectors for interlocking the 2,400 volts and 600 volt circuits so that it is impossible to energize the crossing at the same time from both sources.

Cost of Trolley System.

The total cost of the trolley and feeder system, inclusive of bonding and all changes made necessary in preparing the right of way, was $501,787.74, making the average cost of the overhead system, including batteries and bonding, per track mile, $5,514.00 and per route mile $13,381.00. The principle items tending to increase the cost were a large percentage of curves and special work, high price for all labor, interference of foreign wire, changes in location of tracks, etc., made necessary on account of electrification, extra heavy traffic and the use of 15 miles of same by a transcontinental line, strikes, cold weather, ground conditions and numerous street railway crossings.

Mr. Cox, in discussing the operation of the road, states that the operation has been very successful. He discussed the small difficulties which were met with and told how they were overcome.

Observations of the wear of the trolley wire over the period of two years indicate that the maximum wear was 0.012 in. Using this as a basis a trolley wire life of at least 22 years can be expected. This indicates that 3,041 passages are possible per thousandth of an inch wear of a trolley wire. The roller contacts have given considerable trouble caused by their bearings sticking; this caused the roller to slide, resulting in a flat spot or groove, which rendered the roller unfit for further service. This was caused by the clamps which hold the bearings in place, pressing so hard against the roller that it was unable to rotate; readjustment of the clamps remedied this.

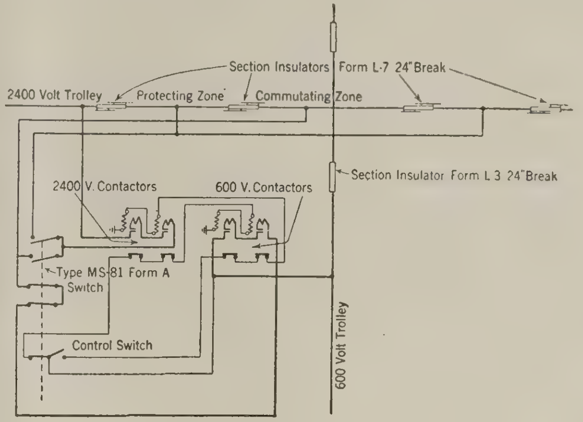


Fig. 6. Diagram of Connection at 600-Volt Street Railway Crossing Showing Commutating Arrangement and Protection From 2400-Volt System With Electrically-Operated Contactors in Series With Regular Commutating Switch.

Sleeve bearings with oil lubrication were fairly satisfactory but oil leakage on the roofs of the cars was objectionable. This lead to a search for a better type of bearing with the result that a special roller bearing is now being used, which about obviates trouble from this source. The average cost of maintenance of the original pantographs with sleeve bearings was about $185.00 per month, or approximately $3.20 per one thousand locomotive miles. The present costs are about 62c per one thousand locomotive miles.

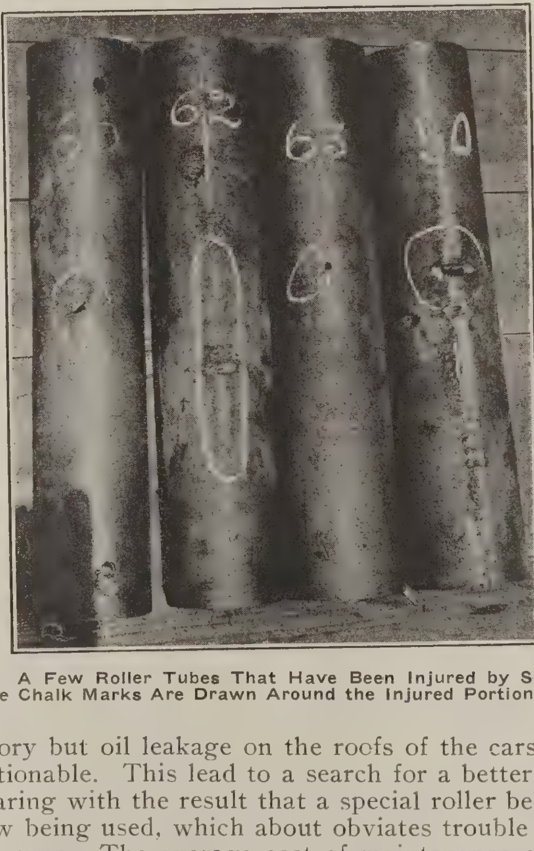


Fig. 7. A Few Roller Tubes That Have Been Injured by Sliding; the Chalk Marks Are Drawn Around the Injured Portions.

Repair work on the 2,400 volt trolley line is done from an ordinary wooden work car without special insulation, but Mr. Cox says, as this would not be safe in wet weather, it would not be hard to construct a tower car which would be suitable under these conditions.

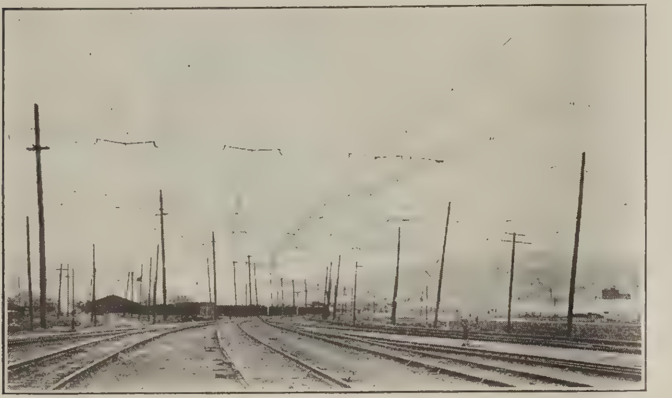


Fig. 8. West End of Anaconda Yard, Showing the Use of a Double Flexible Catenary Pull-Off.

Unique Electrically Operated Lift Bridge.

Over the Willamette River at Portland, Oregon, a unique electrically operated lift bridge is in use. This is a double deck bridge; the lower deck provides for a double track railway in a roadway 32 ft. 8 in. in the clear; the upper deck provides for a double track street railway in a roadway 29 ft. 3 in. in the clear between trusses, besides two cantilevered roadways for vehicle traffic and two sidewalks for pedestrian traffic.

The lower deck may be raised separately to allow tug boats and other small river craft to pass; this does not interfere with traffic on the upper deck. In order that high masted sailing vessels or steamers may pass the lower deck telescopes with the upper deck, and both are raised to a clear height of 140 ft. above high water. The lower lifting deck can be raised to its full height in 30 seconds, and both decks then raise to their full height in 60 seconds.

The entire operation is electrical, direct current motors using 500 volts street railway current being used. The control of the movements of these decks is all in the hands of one man who operates a master remote-control drum.

Electric Ship Propulsion.

As steam turbines give their best efficiency at high speeds and ship propellers at low speeds, the use of gears was made necessary between the turbines and propellers, but to keep the gear ratio within practical limits, the turbine was run lower than its efficiency would warrant, and the propeller faster. Mr. Emmet describes the system which is to be used on the new battleship, California, and which has been used successfully for the past two years on the collier Jupiter. The turbines operate three-phase generators, and these in turn drive the motors on the propelling shafts through control apparatus. In this way all of the machines will be running at their highest efficiency and at least two efficient running speeds will be provided. Further advantage of this system is that it keeps down the total weight of equipment required, and is more compact and rugged than any system which has been used heretofore. Electric drive would result in a saving of about 15 per cent in the coal bill on most modern ships, which means that it would pay for itself in from one to two years.

Contact Conductors and Collectors for Electric Railway

Mr. C. J. Hixson of the railway electrical engineering in a paper with this title gives a general classification of different kinds of current collecting devices. Contact rail and contact wire systems were described along with their corresponding collectors. He derives much data from measurements made upon different types of overhead collecting devices and gives it in the form of curves.

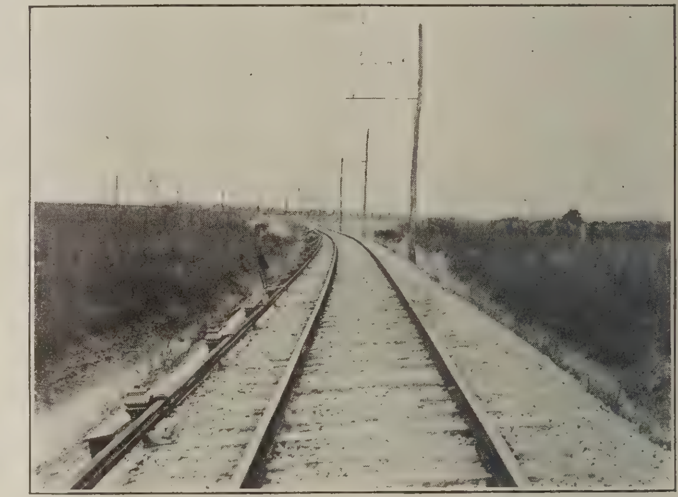


Fig. 1. Unprotected Third Rail With Under Running Contact.

Contact Rail Systems.

These systems of current collection are particularly adopted for elevated and subway work. They have the advantage of high collecting capacity, take up small space, and do not require expensive protection, for the contact rail. But the high initial cost, danger to life, and difficulties from sleet and snow and complications in yards, have been among the factors preventing its wide application to interurban and steam railroad service. Sleet and snow, however, are successfully overcome by inverting the rail and using an under running shoe, but in doing this, the cost is somewhat increased. Higher voltages, however, entail space and greater clearance distances. The use of an inverted

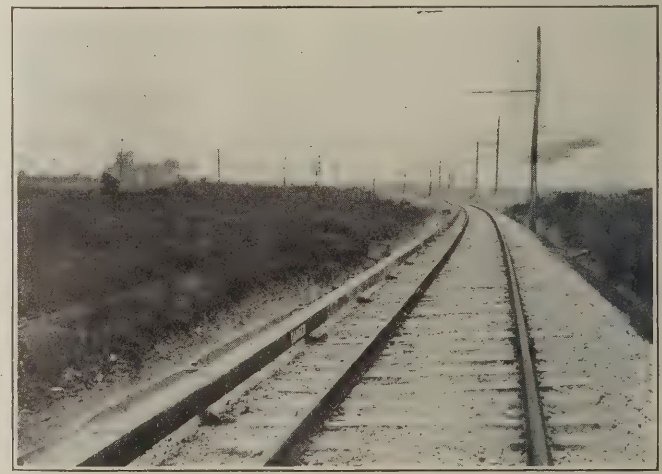


Fig. 2. Same Rail as Fig. 1 With Protection.

third rail with voltages higher than 1,000 make it necessary to locate the insulators in some other position than that now commonly used.

In describing tests made about a year ago, at Schenectady, Mr. Hixson states that it was found desirable in connection with the use of 2,400 volts for an overrunning type of third rail system to increase the horizontal distance of the third rail from the track by approximately 4 in. The third rail shoe is of a special design, due to local conditions, and the slipper with its supporting arm is raised and lowered by compressed air. A cut of this is shown in Fig. 4. The contact arm is folded up against the side of the car when passing through village so as not to project and be a source of danger. When the shoe is not in operation energy is supplied through a slider pantograph trolley.

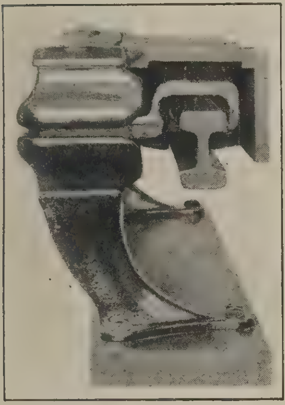


Fig. 3. Third Rail Support and Protection.

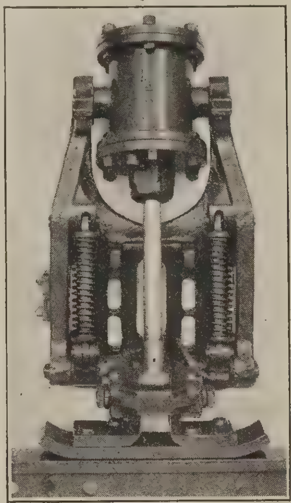


Fig. 4. Third Rail Collector. The Slipper With Its Supporting Arm Is Raised and Lowered by Compressed Air.

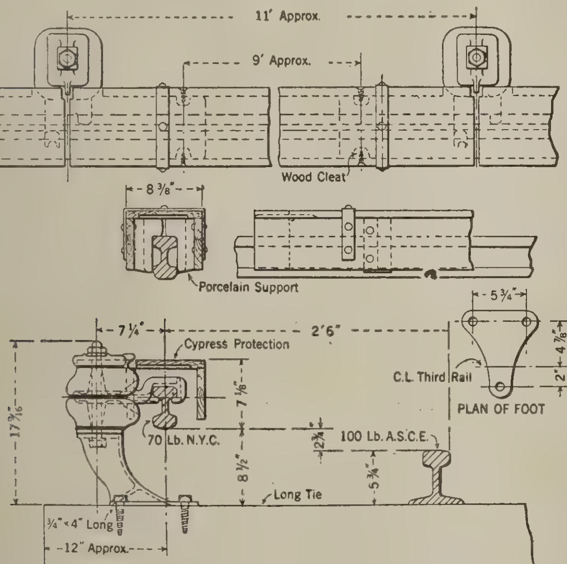


Fig. 5. Showing the Construction and Location of an Under Running Third Rail.

Contact Wire Systems.

Direct Suspension. The direct suspension type of trolley construction has been in use for many years and is standard for conditions involving low speed and moderate amounts of energy 2/0 and 3/0 trolley wire is generally used for city service with a 4 or 6 in. trolley wheel. A 4/0 trolley wire was used in direct suspension with the earlier interurban installations.

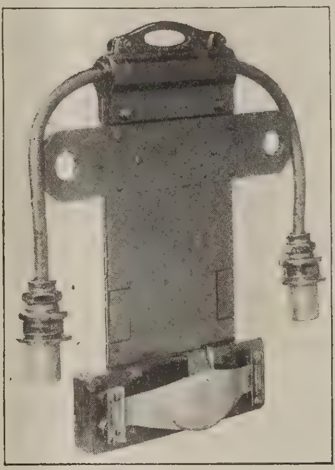


Fig. 6. Underground Shoe for Locomotive of the Type Used Along the Panama Canal.

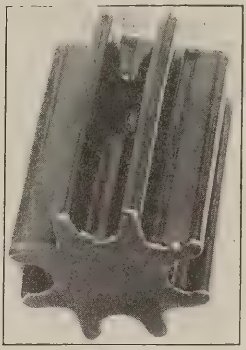


Fig. 7. Porcelain Strain Insulator.

For insulation molded compound, with and without mica, wood and porcelain are utilized. The pole suspension for tangent track has practically been standardized at 100 ft., which is shortened at curves, depending upon the degree of curvature. The type of support is either a cross span wire or a bracket to which is attached a steel strand extending from the end of the bracket to the pole, for the purpose of minimizing the hammer blows of the collecting device. This is the cheapest type of overhead construction.

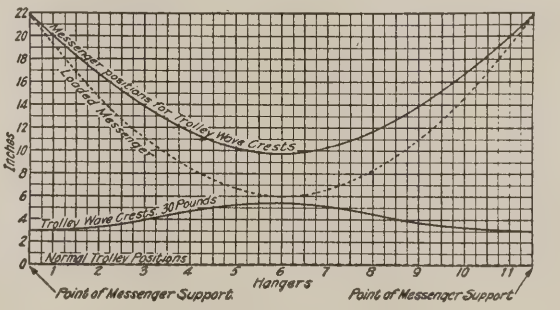


Fig. 8. Curve Showing Trolley Wire Wave Crest for One Span and Corresponding Position of Messenger.

Messenger or Catenary Suspension.

This was orginally developed abroad to comply with safety regulations and to provide more convenient means of insulating high voltage trolley wires. The conditions between the supporting points of the trolley wire was such that in case the trolley wire broke it would not fall to the ground.

There are in existence today, in Mr. Hixson's opinion,

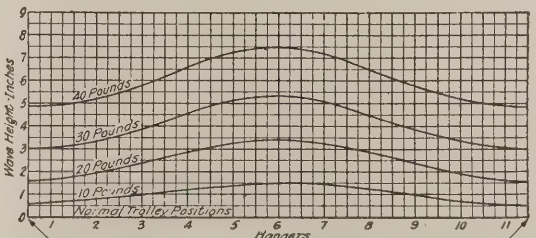


Fig. 9. Trolley Wave Crest Curves at Different Collector Pressures for the Same Span.

certain types of messenger suspensions where it is questionable whether the benefits warrant the additional money spent. Within the last few years it has come to be generally recognized that uniform flexibility is possibly the greatest factor in successful collection. The collector in passing between the wire causes a wave extending 150 ft. or more in either direction. The height of the wave at any point depends upon how elastic the wire is at that particular point. Section insulators, splicing sleeves, hangers and other devices attached to the wire, produce hard spots directly proportional to their weight. The messenger wire is of great assistance in increasing the wave height of the trolley wire, but improperly designed hangers may result in producing a trolley wire supported by a messenger suspension, which will actually give worse collection than with direct suspension for the hangers may cause hard spots that will cause excessive wear of the trolley wire.

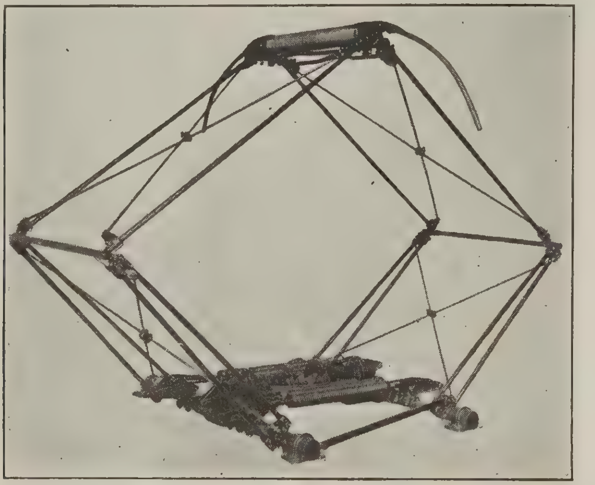


Fig. 10. Roller Pantagraph Trolley. This Can Operate Over a Range as Great as Nine Feet, and the Pressure Against the Trolley Varies From 20 to 32 Pounds.

Mr. Hixson gives several curves in which he shows the variation of the trolley wave crest with different trolley pressures, with different messenger spacing and different types of suspension.

Trolleys.

It is known that the pole supported trolley wheel is much quicker in its action than the heavier roller and slider pantograph trolleys. Since the trolleys must operate over a range in some cases as great as 9 ft., the pressure against the trolley wire varies from 20 to 35 lbs.

Conclusions.

Some of the conclusions arrived at by Mr. Hixson were here given by curves. The variation of the rate of wear with the number of trips with the current collected and with the total contact pressure were plotted for sliding contact current collection. It was found desirable in some cases to employ two trolley wires hung side by side with the supporting points so spaced that the hangers on one wire come midway between the hangers on the other. This resulted in a great improvement in the uniformity of the flexibility of the trolley wire as well as an increase in the collecting and contacting capacity. To show the effect of wind, curves were drawn showing the wind effect at speeds from 0 to 75 miles an hour with different types of catenary construction.

A Japanese Railway Electification

An important electrification of a Japanese Trunk Railway is reported by the Electrical Review of London. The railroad electrified is the Usui-Toge Railroad. It is a line passing through a very mountainous country and goes through some 26 tunnels. It is necessary to overcome a difference in elevation of about 2,000 ft. in a distance of 4½ miles and for this reason this road is designed as a single track mixed adhesion and rack railway. The rack system is constructed with a gradient of 1:15, and the adhesion sections with a maximum gradient of 1:40. In the center of the line the only turn out is situated on a stretch of level ground about 450 ft. in length. The line is of the standard Japanese gauge of 3½ ft. and the rails are secured to iron sleepers to which the triple-bar rack is also fixed.

The electrical energy for the whole plant is obtained from a power station in the neighborhood of Yokogawa, where 3 vertical 1,000 kw. Curtis turbo generators, built by the General Electric Co., have been installed. Current is supplied at 660 volts and 50 cycles. Steam is supplied by 8 water tube boilers fitted with superheaters and automatic stokers of Japanese construction and burning local coal.

Because of the difficulty in securing satisfactory insulation in the narrow tunnels, the comparatively low pressure of 650 volts is used, the adoption of a high tension overhead line, would of course be impossible where the overhead space is so limited.

The electric locomotives are designed on what is known as the mixed system, that is, with separate drives for adhesion and rack operation respectively. A single locomotive can haul 90 tons on a gradient of 67 per cent at a speed of about 6 miles an hour .

The drive is effected by elevated motors and parallel crank mechanism and the locomotive weight of 46 tons is distributed almost uniformly over the three adhesion driving axles, the output of each motor being 350 h.p. at 650 r.p.m. The motor intended for adhesion operation is fitted into the spring suspended main frame of the locomotive and works through a cog wheel transmission of 1 to 6.4 ratio on to the intermediate shaft and thence through a parallel crank mechanism on a loose shaft firmly mounted in resilient frame, when the last drive is effected by means of connecting rods. The current is collected from the under side of the third rail by sliding shoes fixed at the front and rear of the locomotive. On side tracks an overhead line is used and two trolley collectors are provided on top of the locomotive to collect the current in this case.

When running on an adhesion section of the track the adhesion motor alone propels the locomotive and the rack motor runs idle. Synchronism between the rack motor and adhesion motor is obtained by the field of the later being in series with the field and armature of the adhesion motor, while of the armatures of the two motors are connected up in parallel.

On the track section the motors are worked in ordinary series parallel connection with 15 starting steps, the first nine steps connect the motors in series and the remainder in parallel. On the ninth and fifteenth steps the motor fields are shunted. Dynamic braking is used in traveling down hill, the current being dissipated in the resistance which serve for starting.

These locomotives have been in operation for nearly two years. Some difficulty was at first experienced with the parallel crank mechanism, but excellent results have been obtained in the service and the Japanese Railway Department is considering the electrification of other lines.

C. & W. I. R. R. Battery House

The Chicago & Western Indiana R. R. Co., completed in 1909 a battery charging station at their 51st coach yards. This installation, which was described in the July, 1909, issue of the Railway Electrical Engineer consists of a bank of 12 mercury arc rectifiers operating on a 220 volt alternating current circuit, transforming and converting this direct current at a voltage varying from 40 to 350 volts. The details of the rectifier plant and yard distributing system were described in detail at that time so they will not be discussed in this article. Several novel features have been added since then, however, which deserve description, which have been installed by Mr. J. L. Ohmans, Electrical Foreman.

The battery repair house is divided into three main sections, in one of which, the batteries are arranged on benches for charging, a second room is devoted to battery repair, and the last is used for generator repair. The arrangement of the charging circuits is shown diagrammatically in Fig. 1. Here it will be noticed that there are two complete loop circuits which are both contained in a single conduit, which makes a loop of the battery charging room. The receptacles "A" and "B" are in the room adjoining the battery charging room. If it is desired to charge several sets of batteries, these are plugged into the receptacles "b." Then to complete the circuit a duplex conductor having two plugs puts the receptacle "C" in series with the charging circuit. In series with receptacle "C" are an ampere hour meter and an ammeter, so in this way the charge given the batteries can be exactly controlled.

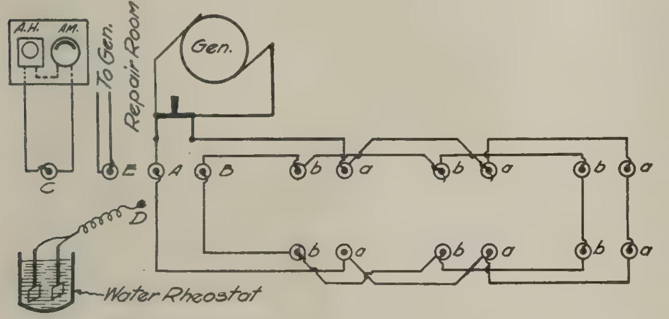


Fig. 1. Diagrammatic Representation of the Wiring in the Battery Charging Room of the C. & W. I. Battery House.

If more batteries are required to be charged than the "b" receptacles can accommodate, the remaining batteries may be plugged into the "a" receptacles. This circuit is connected into parallel with the line by connecting receptacle "B" in multiple with receptacle "A."

Another possibility of this wiring arrangement is the discharge of batteries. If it is desired to discharge a number of batteries they are plugged into the "a" receptacles and the circuit is closed by connecting plug "D" into receptacle "A." This connects in a water rheostat which is shown in the sketch electrically connected to plug "D."

When it is necessary to use batteries for experimental purposes, such as the motoring of generators, etc., batteries to be so used are plugged into the "b" receptacles. Receptacles "B" and "E" are then connected together, receptacle "E" being connected to the terminals of a line going into the axle generator testing room. This makes a very flexible arrangement and makes it possible to charge any number of batteries by means of only two conductors in the battery charging room.

Ingenious Method of Taking Battery Voltage.

For reading the voltage of the batteries a scheme has been worked out which is shown diagramatically in Fig. 2. Two volt meter leads are carried through the conduit to the center of the battery charging room, from here a duplex wire encases the two leads, is connected at the point "a" to a string which passes over a pulley and is connected. All that is necessary to read the voltage of a battery is to take the two terminals marked "Positive" and "Negative" and connect them on to the battery. The terminals can be carried to any part of the battery room to take a reading. When they are not needed they are carried back to an out of the way place against the wall by means of the cord passing over the pulley. This obviates the use of a large number of voltage leads running to the separate sets of batteries.

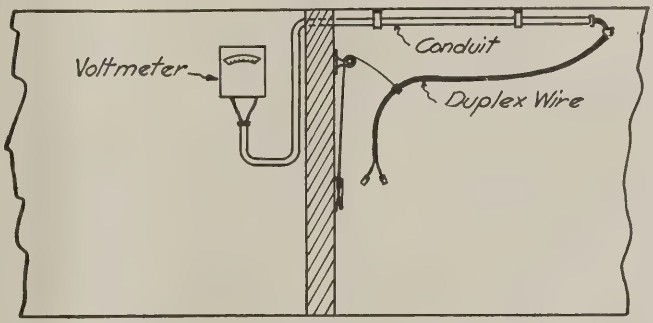


Fig. 2. Flexible Duplex Cable Used in Reading the Voltage of the Batteries in Different Parts of the Room.

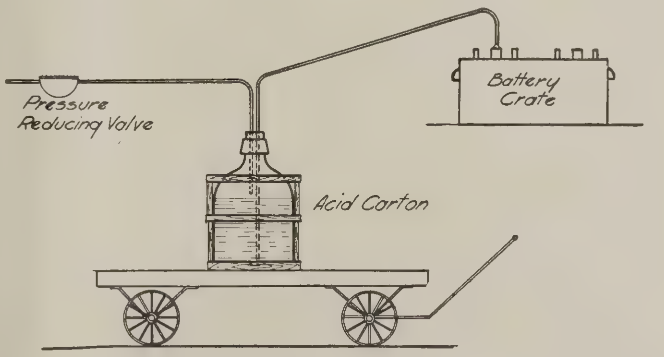


Fig. 3. Acid Carton Mounted on Truck, Showing How Air Supply Is Used to Elevate the Acid Into the Battery.

Supplying Electrolyte to Batteries.

The method for forcing acid into batteries is shown by Fig. 3. The carboy of acid which is shown mounted on a small 4-wheel truck is fitted with a 2-holed rubber stopper, through one hole a short pipe just extended through the plug is connected to the air supply. An acid proof pipe extending to the bottom of the acid container extends up through the stopper and is connected to a rubber hose through which the acid passes to the battery. The air pipe passing through the battery house contains air at a pressure of 80 lbs., which is too high a pressure to use for this purpose; so use is made of a gas reducer to step this pressure down. It was found at first that sufficient air could not be supplied as air has a greater viscosity than gas, but by piercing a small hole through the diaphragm in the gas reducer this trouble was obviated. In this way the available pressure from the supply end of the air pipe is reduced to about 10 lbs., and this pressure is regulated somewhat by one of the attendants helping to fill the batteries by leaving the stopper loose in the acid carton. The flow in this way can be controlled and stopped when the battery is full.

Scheme for Checking Batteries.

Whenever a new set of batteries comes into the house they are given a number and nine tags are made with this number on it for their identification. One tag is placed on each tray of the battery and the ninth is used to keep the battery located. On the tag is placed the date when the battery was new, the railroad's name and the make of battery. There are two boards which are divided up into a number of squares. One board is devoted to the C. & E. I. R. R. Fig. 4 shows this board, the number above each square refers to a car on that road. The lower center of the board on the right is marked "House." Here the tags are placed for all batteries coming into the battery house for any reason. So if a certain battery is brought into the battery house for repair the the identification tag of this battery is placed on the battery house board on the square designating the particular battery bench occupied. Portions of this board are allotted to other railroads making use of this yard. Each square in this case represents a certain car upon which batteries may be placed.

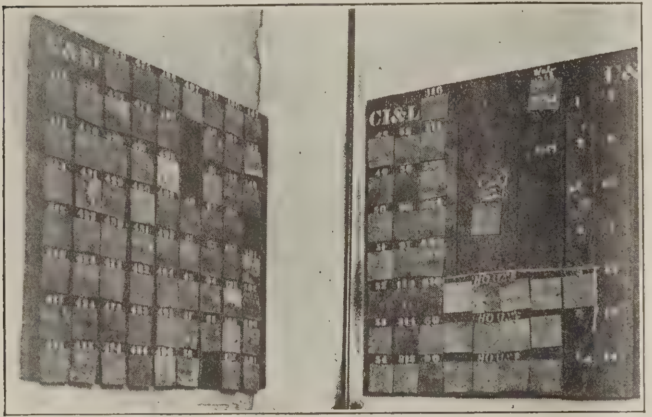


Fig. 4. This Shows the Two Boards Upon Which the Battery Identification Tags Are Kept. A Battery Being Placed on a Certain Car Is Recorded by the Tag Representing That Battery, Being Placed on the Square Representing the Car.

If one of the batteries is to be removed from the battery house to a car on the C. & E. I. R. R. the identification tag of this battery is removed from the battery house board to the square representing the particular car of the C. & E. I. upon which the battery was placed. This makes a very easy method of keeping track of batteries and in this way any particular battery can be located or the number of the battery in any particular car can be instantly told by referring to the board.

Northern Pacific Electrification.

A number of the officials of the Northern Pacific R. R. are now meeting at Giant Falls, Mont., and looking over the water power possibilities at that place. It is rumored that the railroad intends to electrify the road from this point into St. Paul, and that the electrification of the first division which is 114 miles in length will begin on October 15th.

There is very heavy traffic over this road and conditions are very similar to those on the Chicago, Milwaukee & St. Paul, who are electrifying their line between Harlowton and Three Forks, Montana. This electrification has already been described in the RAILWAY ELECTRICAL ENGINEER. The decision of the Northern Pacific will be met with a great deal of interest as this will be the second large trunk line electrification in the state of Montana.

No details were given as to the system which is contemplated but presumably it will be a high tension direct current system.

The abundance of water power in Montana makes it only logical to begin operations in this state and as some of the heaviest grades occur at this point electrification will aid greatly in handling the traffic.

Conditions Affecting Main Line Electrification.

Mr. W. S. Murray in discussing railroad electrification defines a successful electrification as one that is, (1) a success for the public; (2) a success for the railroad; and (3) a success for both the public and the railroad. Naturally the third is the greatest objective as the railroad is anxious to have its electrification considered as successful by its patrons. To be truly successful, however, it must follow the lines laid down by good business. In his opinion all motive power equipment should, if possible, be designed for operation upon one form of current. He shows that under the single phase high potential contact wire three types of electric motive power—the single phase, the three phase and the direct current, through the medium of a rectifier—can operate. Thus each class of equipment is permitted a uniform supply of power.

In this way a standard system of power distribution from the contact wires is established, with which power can be delivered in a standard and unchanging form. His experience, which has been gained through the observation of several large single phase lines, indicated that economy can be secured in the following ways: (1) Saving of fuel; (2) saving in motive power maintenance and repairs; (3) saving in train miles. In the matter of train miles the saving to be effected is dependent upon local conditions. The economy of the electric locomotive is well known and coal burned under the power plant of a supply station will produce more power than on the grates of a steam locomotive. Density of traffic and other factors have to be taken into consideration. Electric locomotives of about 100 tons on the drivers should be maintained at a rate not exceeding 5c per locomotive mile. The coal bill for transportation is cut to at least one-half. If these savings will cover the interest, insurance, depreciation and taxes on the electrical investment, then an electrification may be said to be justified.

The Schomburg & Aurora Railroad is reported to have plans complete for electrifying that portion of their line which extends near Bond Lake to near Lloydtown, Ontario. Part of the material has been ordered.

Shop Motor Section

Electrically Operated Coal Hoists

J. H. Wickman

Tenth Article

The method of loading coal into storage bins preparatory to its use in locomotives in times past has been to run the car up a long incline and then dump by gravity into the containing hopper. This method is uneconomical, however, for all the power used in elevating the car is wasted. In modern coal loading stations the coal is dumped from the cars into a hopper underneath the track, from there is elevated by means of a bucket hoist into an elevated storage bin. This method has the advantages of being more economical, having a lower first cost, and of being a less fire risk, because it is not necessary for an engine to be run over the coal hopper.

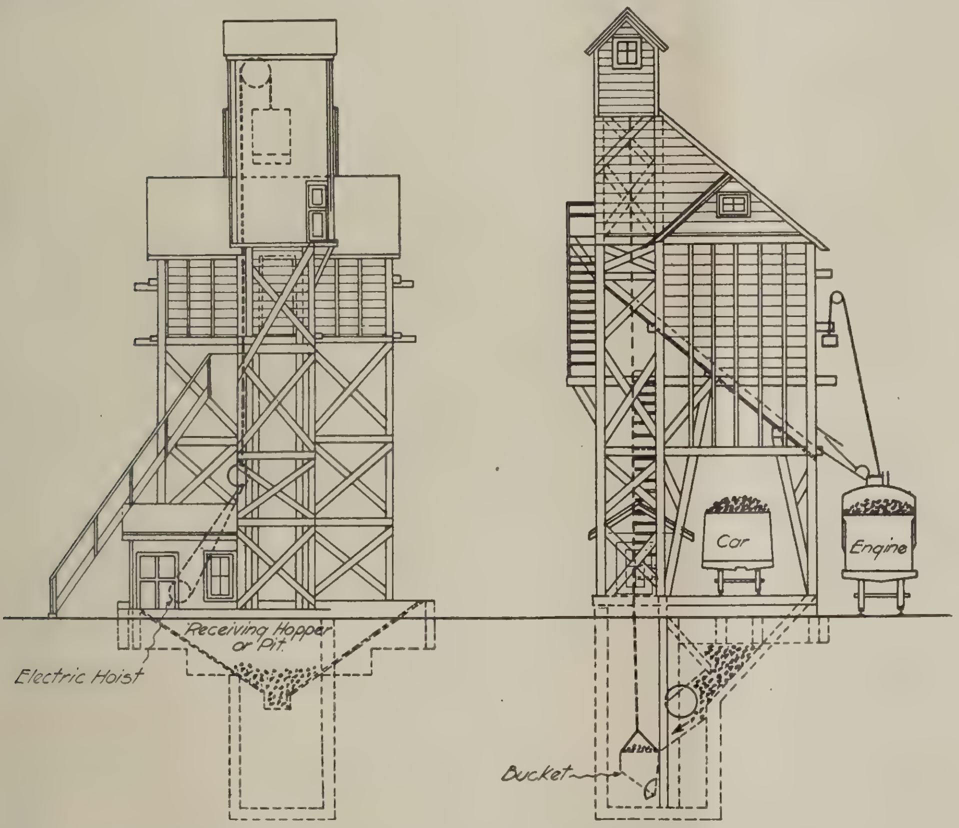


Fig. 26. Front and Side View of a Typical Electrically Operated Coal Hoist, Bucket Conveyor is Shown at Top in Left Hand Diagram and at Bottom, Being Filled, in the One at the Right.

In most of the modern plants now being built, provision is made for the loaded cars to be backed over the dumping pits and emptied. There is an opening at the bottom of this pit through which an amount of coal is automatically released, equal to the capacity of the elevating bucket if a single bucket is used. The arrangement will be somewhat different if another hoisting device is used. As the bucket is lowered into the shaft under the pit, it is automatically filled with coal, and as it rises the trap door in the bottom of the loading hopper closes and admits an amount of coal sufficient to fill the bucket on its return trip.

In the present article we are not so much interested in the mechanical details of these hoists as we are in the application of electricity to this class of work.

Electric power has been used to operate bucket conveyor operation in a variety of ways. These will best be understood by keeping the mechanical and architectural details of Fig. 26 in mind. The different schemes will vary in some particulars from the one shown, but the fundamental arrangement is the same. Each of these different types of construction will be taken up under a separate head, and in a future article the cost of operation of these different types of construction which are described below will be given.

Belt Conveyor. Method No. 1.

The coal passes from the bottom of the unloading pit through a crusher, which breaks the larger lumps of coal to the required size for engine use. An endless belt, operated by a 25 h.p. electric motor, carries the coal on a suitable incline to the overhead coal container. Two 3-phase, 60-cycle, squirrel cage induction motors of 25 h.p. capacity are used in this case. One of the motors is used to run the crusher which breaks the coal into pieces small enough to be burned in a locomotive. The belt is run at a speed of about 1½ ft. per sec. by the other motor. Both motors are started from the same starting box and are run continuously while the cars are being unloaded. Under full load conditions this equipment can handle from 50 to 60 tons per hour.

Bucket Chain Conveyor. Method No. 2.

This method of handling coal is used to some extent by railroad companies, but finds a much greater application with power companies to fill their overhead hoppers where the coal is fed into the furnaces by gravity. As in the first method, the coal is emptied into the dumping pits. These contain a motor driven shaker or bucket feeder at the bottom, which is driven by a constant speed motor requiring from 5 to 7½ h.p. The coal is then delivered from the shaker to the crusher, from where it is carried by the bucket conveyor to the overhead container. The buckets are constructed of sheet iron and hold from 80 to 100 lbs. of coal each, and are spaced on the chain conveyor 3 ft. apart. The bucket chain is supported at either end by a large sprocket wheel, and is run by a 20 h.p. motor at constant speed. It is kept in operation all the time that coal is being unloaded and the speed of the bucket travel is about 1 ft. per sec.

An installation similar to the one shown in Fig. 26, which has a 250 ton capacity, would require from 65 to 70 buckets. These buckets dump automatically into another small hopper at the top of the container. There is a coal crusher at the bottom of this small hopper which is either driven separately by a 15 or 20 h.p. motor or else by the conveyor motor. When this system is used by power companies to distribute coal in several different bins, the crusher is located at the bottom of the receiving hopper or pit.

One of the advantages of this system over the preceding one is that the buckets are held right side up by gravity and are fastened to the sprocket chains by means of small bearings. The coal can be elevated straight up to the required height and then turned at right angles and carried over the top of overhead hoppers. The trips can be set so that certain buckets may be dumped in one place and others at another, thus distributing coal if necessary across the entire length of the boiler room or into bins feeding chutes on both sides of the boiler room. With this apparatus about 50 tons of coal can be loaded and crushed per hour if the coal is wet, and considerable more if dry coal or screenings are handled.

Automatic Chain Bucket Elevator. Method No. 3.

This may be called a combination method of elevating coal, for it is merely an ingenious mechanical device electrically driven.

A 10 h. p. constant speed induction motor is direct connected to an automatic mechanical reversing drum which is attached to the elevating bucket by means of steel cable, the bucket being over-counterweighed. The cycle of operations is as follows: When the motor is started the bucket is lowered into the pit and automatically filled; the mechanical reversing worm gear is so timed and set that it reverses the hoisting drum at the instant the bucket is filled and starts elevating the bucket. As the bucket nears the top of its travel, the trap door, which is built in its bottom, engages a latch, which opens it and dumps the coal; here again the timing of the mechanical reversing gear starts the bucket on its downward journey as soon as it has been emptied.

The capacity of this type of conveyor is from 40 to 60 tons of coal per hour, but when the cars are being unloaded and the lumps broken up by hand, the hoist will not be required to handle more than from 30 to 50 per cent of this amount.

There are several other methods of hoisting coal in use at the present time—hand controlled electrically operated hoists, automatic electrically operated chutes, and others which are less important. A description of some of these methods will be given next time and the operating costs of the various types discussed.

Errata.

In last month's article on the "Speed Control of Induction Motors," credit for the motor described under the head "New Type of Automatic Starting Motor" on page 84, should be given to Fairbanks Morse & Co.

The Principles of Alternating Currents

Williard Doud

Sixth Article

The question of wattless current is of great importance in the study of alternating currents, as practically all alternating current circuits contain inductance or capacity effects. It has been shown that with inductance or capacity in a circuit, a certain portion of the energy delivered is used to overcome the friction or resistance of the circuit or apparatus in the circuit and is lost, while another portion, which does not perform any useful work, is returned to the generator and comprises what is termed wattless current.

In a circuit containing inductance, it has been shown in Figure 19 of the July issue that the curve of values of self-induced electro-motive force does not correspond with the curve of values for impressed voltage, but lags behind it and has a lesser value.

The resultant voltage, which is in step with the current, was shown to be the simple arithmetical sum of the other two curves, remembering that values above the line are positive and values below the line negative. So when values above the line are added to values below the line, the difference in signs makes it a subtraction.

In the measurement of alternating current it is possible to determine the value of the impressed voltage with the voltmeter. We also can obtain the actual amount of current flowing by use of the ammeter. We have no obvious means of determining the resultant electro-motive force, which is the real electromotive force, which must be multiplied by the current flowing in order to obtain the true power. If the current values are multiplied by the values of the impressed voltage curve, the results will be too high, because part of this power is returned to the generator.

The current multiplied by the impressed voltage is termed apparent power or volt amperes. The current multiplied by the resultant voltage is termed true power or true watts.

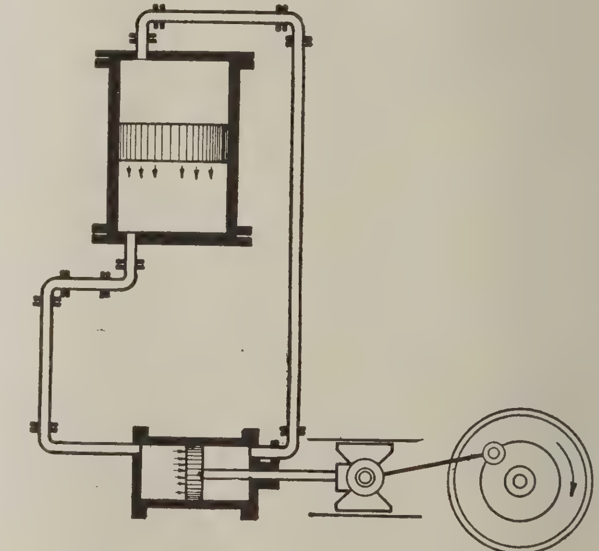


Fig. 22. Hydraulic Analogy of Wattless Current. The Engine Does Work in Raising the Large Piston in the Upper Cylinder During Half the Cycle. This Is All Returned to the Engine, However, When the Bottom Piston Is Moving to the Right.

The ratio of the apparent power to the true power, or the true power divided by the apparent power, is called *power factor.*

This term is a very important one in the treatment of alternating current problems. The power factor expresses the percentage of the apparent power which is represented by the true power and is always expressed as a decimal fraction, thus .85.

In the measurement of direct current it will be remembered that the elementary formula $C = \frac{E}{R}$, and its modifications $E = CR$ and $R = \frac{E}{C}$, expressed all conditions entering into power problems.

With alternating current, a motor which is consuming 30 amperes at 200 volts and has a power factor of .90, is not consuming 6 kilowatts, but $30 \times 200 \times .90 = 5.4$ kilowatts. The generator which supplies current for motor does not deliver 5.4 kilowatts but the full amount or the apparent watts and has .06 watts returned to it.

The matter of power factor must always be taken into consideration in determining the size of generator to operate a given number of alternating current motors, or an alternating current circuit to carry a given amount of power. The power factor of an alternating current circuit is the ratio of the power as read on a wattmeter to the product of the volts and amperes as indicated by a voltmeter and an ammeter respectively.

The size of generator and the conductors must be sufficient to carry its full rating of true power plus the wattless current. A 200 kilo-volt-ampere generator operating at 80 per cent power factor will give a true power output of 160 kilowatts.

Under certain conditions it would be possible for a generator to be carrying full load current, but for the current to be so shifted in phase with reference to the impressed voltage as to produce very little transmission of energy to the circuit, in such a case the power factor would be near zero. In this instance the greater portion of the energy would be returned to the generator, causing it to run as a motor during a part of the cycle. While under this condition the generator is transmitting very little power, the generator wires are carrying current for full load conditions and the heating effect is the same as it would be with full load. It is for this reason that alternating current machinery is given a kilo-volt-ampere instead of a kilowatt rating.

The hydraulic analogy of wattless current is shown in Fig. 22, which, however, is not entirely exact in its relation to electric circuits, in that the subject of inertia is not taken into consideration.

In Fig. 22 is shown a horizontal cylinder containing a piston operated by power and a vertical cylinder, the bottom and top of which are connected to the ends of the horizontal cylinder by piping. In the vertical cylinder is a heavy piston, which moves up and down freely and follows the action of the piston in the horizontal cylinder through the medium of a fluid which fills the piping and both cylinders.

As the horizontal piston is driven from right to left, a current will flow through the pipes and the vertical piston will be raised. As the horizontal piston moves from left to right, the vertical piston will fall, and adds its power in falling to driving the horizontal piston from left to right, thus returning the energy imparted to it during the first part of the cycle minus friction losses.

The total energy expended in raising the piston in the vertical cylinder, therefore, is that due to frictional losses alone, for all the work done in raising the floating piston is returned by the latter when it is falling. The power factor in such a case would be the ratio of the actual energy expended to the value represented by the product of the pressure by the rate of flow. If there were no frictional losses, so that all of the energy spent in lifting the piston in the vertical cylinder was returned to the horizontal piston when it fell, then the current might be called wattless or workless and the power factor would be zero.

When an electric current flows through a coil of wire, a magnetic field is built up about the coil and may be likened to a number of elastic bands which are stretched by the action of current. When the current is stopped or reversed in direction, the magnetic field collapses, and the energy which was stored in the magnetic field is returned to the circuit. Thus it is evident that when an alternating current flows through a coil, energy is alternately stored in the magnetic field about a coil and returned to the circuit every time the current reverses its direction. Therefore the product of the pressure by the current does not represent the actual energy delivered to the circuit, as was shown when capacity and inductance effects were discussed.

The Railroad Electricians' Club

Edison Storage Battery Questions

(Continued from last month.)

Ans. 31—Continued.

The constant potential system of regulation is somewhat similar to the combination current voltage regulator except that at the beginning of charge the current is allowed to rise to a much higher value than when the current limiting regulator is provided. Summing up then: with a constant generator current regulator the battery charging current is a very uncertain value. It may be high or it may be low, depending upon the number of lamps in use at the time; therefore, this type of regulator would probably not give as good service with the Edison battery as the other types, for the battery might be frequently charged at a low rate. With a constant battery current regulator, the current to battery is maintained constant at all times. The regulator setting, however, should be at least 40 amperes for the A-8-H type cells, which are standard in car lighting work. Where it is possible to set the regulator at this value this type of regulator should give very satisfactory charging of the battery, but a 60-ampere or normal rate setting is preferable.

In the combination current voltage regulations and with the constant potential regulators, the battery current usually starts at a high value of about 65 amperes and tapers off to a low value at the end of charge. This provides ideal charging for the Edison battery for if the battery receives a high rate at the beginning of charge there are no bad effects if the current tapers off at the end of charge.

Effect of High Rate.

Q. 32. What effect do high current rates on charge or discharge have on the battery?

Ans. 32. Manufacturers state that the only effect which high current rates on charge or discharge have on the battery is to heat it and this is the only limitation that is placed on high rates for either charge or discharge.

Q. 33. What is the highest current rate allowable?

Ans. 33. About 1000 amperes have been taken from the A-8-H train lighting type battery nine successive times, the battery being short circuited to complete discharge in each case in tests by the manufacturers, without apparent injury. Such current values would be out of the question for car lighting service. As a general proposition it may be stated that the current rate on charge or discharge may be any value desired so long as the battery temperature does not go above 115 deg. F.

Testing Battery Conditions.

Q. 34. How can the practical car lighting man tell what the condition of the battery is when received at the yard?

Ans. 34. The driver of an electric car after he has become accustomed to handling the battery is able to "feel" his battery and tell fairly well what the condition of charge is by how the battery responds. The car lighting inspector or yard electrician taking care of Edison car lighting batteries can after a time "feel" the voltage condition of his battery with fair accuracy.

A practical test is to turn on all lights for about 5 minutes and the brilliancy of the lights after this discharge gives an indication of what the condition of the battery is.

Corrosion of the Terminals.

Q. 35. How can the car lighting inspector locate a poor contact at the cell terminal, and what should be done to remedy the trouble?

Ans. 35. The car lighting inspector should occasionally feel of all terminals of the battery. This can be done quickly and if the battery has been on heavy charge or discharge for some time previous any terminals with poor contacts will be warm. If any such are found the connector should be removed and the tapered terminal post cleaned with a strip of emery paper by pulling the strip back and forth over the surface as a boot-black handles his shining cloth. The inside of the connector should also be cleaned and this can be done by rolling the emery paper into a cone shape with the emery side out and the cone tapered about the same as that of the connector. This placed over the end of the finger and twisted back and forth inside of the connector will soon clean the surface of the taper. Should this fail, apply a new connector.

What Happens When the Battery Fails?

Q. 36. When the battery capacity is finally exhausted through long service, what causes failure; does the active material come out of the tubes similiar to the gradual erosion of active material in lead batteries, or do the plates themselves go to pieces?

Ans. 36. There is, of course, a slight amount of active material which is mechanicaly removed from the pockets and tubes of the plates when new. The decrease in battery capacity at the end of battery life, however, seems to be caused more by a change in the physical condition of the active material itself. Even most careful chemical analysis has failed to definitely determine just what this change is. The manufacturers state that they are able to remove the active material from an exhausted battery and return it to active condition and again replace it in the plates, whereupon it will give normal capacity.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 44

The Gould Lamp Regulator

Although the voltage coil of the generator regulator prevents the voltage of the generator from rising above 40 volts, this maximum voltage would severely strain the lamps, were it allowed to be impressed directly upon the lamp circuits; moreover, the charging voltage with the battery in a low state of charge may be as low as 34 volts. Therefore the lamp regulator is inserted to absorb the 6-volt variation between charge and discharge conditions of the battery, and to maintain the lamp voltage constant regardless of whether there be a large number or a small number of lamps in service.

In order to obtain this regulation, the varying resistance principle of the carbon pile is employed. It has been fully explained in previous lessons how the resistance of a pile of carbon discs may be varied over a considerable range by varying the pressure on the pile of discs. Increasing the pressure will decrease the resistance of the pile and accordingly decrease the voltage drop absorbed in the pile and consequently raise the lamp voltage. On the other hand, decreasing the pressure on the carbon pile will increase its resistance and accordingly increase the voltage drop of the lamp current flowing through the carbon pile and therefore decrease the voltage impressed on the lamps.

The lamp current passes through the two large carbon piles shown near the top of Fig. 220, the current passing through the two piles in series. An equalizing bar is mounted at the left end of the two piles and this, being pivoted at the center, equalizes the pressure on the two piles. Equalizing the pressure will usually equalize the resistance and the heating effect in the two piles, but if for any reason whatever the resistance of the discs or contact resistance of one pile becomes higher than that of the other, due to collection of dust or particles of sand or cinders between some of the discs, etc., there will be an uneven distribution of heating in the two piles and the pile having the most resistance will, of course, get hotter than the other, arcing and burning the carbons. While this might not affect the operation of the regulator, it will be liable to injure the carbons and accordingly the carbon pile and discs should all be kept as free as possible from collection of dust and cinders.

As stated before, the pressure on the carbon piles determines the voltage drop of the lamp current in flowing through them. The necessary variation in pressure on the carbon pile is produced by means of the main solenoid 17, Fig. 220, the magnetic pull on the plunger being transmitted through the top horizontal lever "2M," Fig. 220, to the vertical lever at the right end of the carbon piles. It will be noted that the lever "M" pivots at the stationary bearing 12 and this lever, connects to the vertical lever 9 at the pin 13. A pin 14 connects the vertical lever 9 with the pressure plate of the carbon piles U, U′. The fulcrum, or pivot point of this lever is the bearing pin 15, but it should be noted that this is not absolutely stationary, for the vertical lever "G" swings through a slight angle at each stop and start, about the stationary bearing 16 as a center. The exact operation of this will be explained later.

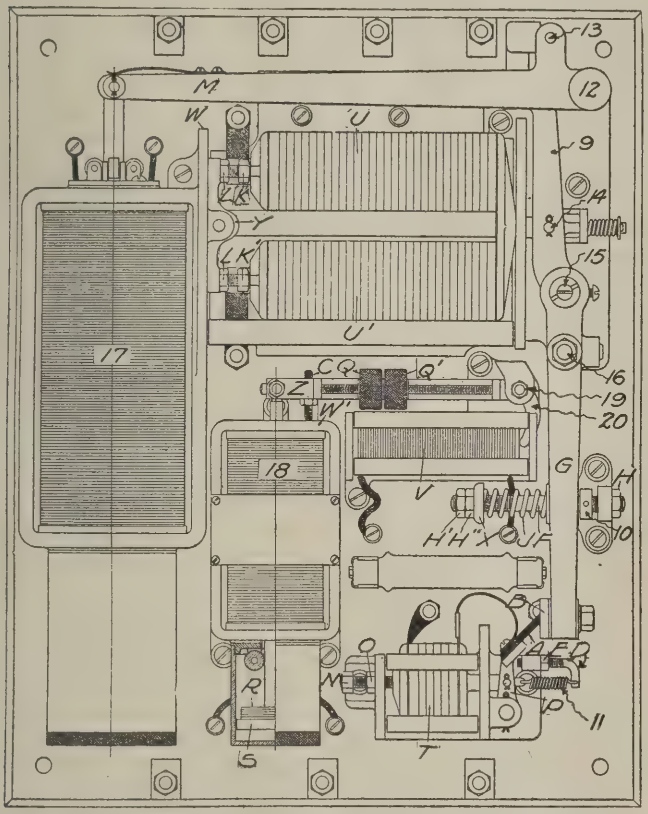


Fig. 220. Gould Type "M" Lamp Regulator.

The Multiplier.

In order to make the action of the large regulating coil 17, Fig. 220, very sensitive to slight variations in lamp voltage, an auxiliary coil or multiplier 18, Fig. 220, has been added. The windings of this coil 18 are connected directly across the lamp circuit so that it receives all variations in lamp voltage. The magnetic pull of the coil 18 on its plunger is transmitted through the horizontal lever "Z," which is pivoted at the point 19 and has a finger 20, which projects downward and bears against the small carbon pile "V."

This carbon pile is connected in series with the windings of the large regulating solenoid 17. A slight rise in lamp voltage will increase the magnetism of the coil 18 and this, pulling up more strongly on its plunger and acting through the lever "Z," will increase the pressure on the carbon pile "V." An increase in the pressure of the carbon pile "V" will considerably decrease its resistance and since the resistance of this pile is in series with the windings of the main coil 17, this will cause a comparatively large increase in the current flowing through that coil. The magnetism of the coil 17 will thus be strengthened and will pull up more strongly on its plunger, and this, acting through the levers "M" and 9, will release the pressure on the carbons U, U′, thereby increasing their resistance and cutting down the voltage impressed on the lamps to compensate for the slight rise in voltage.

A decrease in the voltage impressed across the lamps will cause just the reverse action, the current through the multiplier coil 18 will decrease slightly, allowing its plunger to fall a trifle and the pressure on the carbon pile "V" will be slightly decreased, increasing its resistance. The increase of this resistance, which is in series with the main coi 17, will cause the current through that coil to be decreased and with the decrease in magnetism of that coil, will allow its plunger to fall slowly. This motion being transmitted through the levers "M" and 9 will increase the pressure on the carbon piles U, U′, decreasing their resistance and thereby allowing the voltage impressed across the lamps to be slightly increased to compensate for the fall in lamp voltage. In this manner the lamp voltage is maintained practically constant at all times and the multiplier coil 18 makes the action of the main coil 17 very sensitive to slight variations in lamp voltage.

Short Circuiting Carbon Pile.

Another auxiliary carbon pile "T" is added at the lower right hand corner of the panel board, Fig. 220, and this is composed of six carbon discs. The circuit of this pile is normally open but when the lamp voltage falls below normal, this pile is automatically connected in parallel with the main carbon pile, short circuiting it so that the resistance in the lamp circuit will then be reduced to a minimum. The pressure on the pile "T" is produced by the lever "G," which also serves to make contact with the brush "A," connecting the short circuiting pile "T" in parallel with the main carbon pile at the proper time.

Action of the Regulator.

When the lamp voltage is slightly below the full setting of the regulator, as when the car is at rest, the main carbon pile of the regulator will be short circuited by the auxiliary carbon pile "T." The lever "G" has been swung over to the left by the action of the main plunger being lowered in the coil 17; this causes the contact block "B" to bear against the brush "A," making a wiping contact and connecting the carbon pile "T," which has very low resistance, in parallel with the main carbon pile U, U′.

After the train gets up to speed and the automatic switch cuts in, the generator voltage, rising so as to charge the battery, increases the lamp voltage slightly above normal. The multiplier coil 18, then compresses its carbon pile "V" and allows the current through the main coil 17 to increase and this pulls up its plunger and raises the horizontal lever "M" slightly off the stop "W." Up to this time the carbon piles U, U′ have been very strongly compressed by the weight of the plunger acting through the lever "M," so that their resistance has been a minimum. As the lever "M" rises slightly off the stop "W," it will cause the pin 13 to move to the right and tend to allow the lever 9 to lessen its pressure on the main carbon piles U, U′. The pressure of the spring "J" against the lever "G," however, forces the pivot pin 15 to the left as the pin 13 is moved to the right, so that the pin 14 will remain stationary and the maximum pressure be maintained on the carbon piles U, U′, as the lever "M" is first raised.

As the pin 15 is allowed to move to the left the spring

"J" forces the lower end of the lever "G" to the right. This releases its pressure against the brush "A" and lever "P," so as to decrease the pressure on the carbon pile "T" and this gradually increases the resistance of the short circuiting carbon pile "T." The movement of the spring "J," however, soon forces the lever "G" against the lock nut at the right side of this lever and prevents further motion of "G." Meanwhile, however, the contact of the brush "A" on the block "B" has been broken so that the circuit of the carbon pile "T" is now completely opened by the spring "J"; the pin 15 then becomes stationary and acts as a fulcrum for the lever 9.

Then as the generator voltage rises slightly higher, and the lever "M" is further raised by action of the multiplier coil 18 and main coil 17, the pin 13 will be moved still further to the right. Since the bearing pin 15 is now stationary, this will cause the pin 14 to move slightly to the right, decreasing the pressure on the main carbon piles U, U′. A further increase in train speed and rise in generator voltage will cause the lever "M" to be raised still higher and still further lessen the pressure on the main carbon piles, thus increasing their resistance so as to compensate for the rise in generator voltage and maintain constant voltage on the lamps.

On decrease in train speed the reverse operation takes place. The lever "M" falls gradually, thereby increasing the pressure on the main carbon piles U, U′, which decreased their resistance and maintains lamp voltage constant. As the train speed and generator voltage continues to decrease, the lever "M" will be gradually lowered until maximum pressure is brought on the carbon piles U, U′. The pin 14 will then become stationary and as the pin 13 is moved still further to the left by falling of the lever "M," this will cause the pin 15 to be moved slightly to the right. Since the lever "G" is pivoted at the point 16, a movement of the pin 15 to the right will cause the lower end of the lever "G" to move to the left, bringing the contact block "B" against the brush "A," and connecting the carbon pile "T" across the terminals of the main carbon pile. A further decrease in train speed and generator voltage will allow the lever "M" to fall until it bears against the stop "W" and this motion being transmitted through the levers will cause the lower end of the lever "G" to be forced strongly over to the left, solidly compressing the carbon pile "T," thereby making practically a dead short circuit across the terminals of the main regulator carbon piles U, U′, and allowing the lamps to receive the full battery voltage, provided this does not excel the normal lamp voltage.

Setting the Regulator.

The adjustment of the main lamp regulator is purely a mechanical operation and has no reference whatever to voltage or current; therefore, this can best be done while the equipment is at rest in the yard. First relieve pressure on the main carbon pile by blocking the lever "M" up about 1 inch above its stop "W." This will relieve pressure on the main carbon pile and at the same time open the contact between "A" and "B" at the lower end of the lever "G." The short circuiting carbon pile and its contacts should be adjusted first. To do this, remove the tension spring 11 from the stud "D," then unlock the nut "E" and turn the stud "D," which forms the stop for the lever "P" until the brush "A" makes a full surface contact on the contact block "B" when the lever "G" is pulled to the left by hand. This contact should be slightly stronger on the toe than on the heel of the brush "A," so that when the contact is closed by hand the laminations of the brush "A" will open slightly and each make a good wiping contact on the block "B." Then lock the stud "D" with the nut "E" and replace the spring 11 which tends to open up the carbon pile "T."

Then re-adjust the stud "F" until the block "B" is exactly 1/16 inch from the tip of the brush "A." Next, by means of the cap screw "N," adjust the short circuiting carbon pile "T" so that with the carbon plates normally in loose contact, the brush "A" can be pulled to the left just 1/32 inch, this making a total space between the tip of the brush "A" and contact block "B" of 3/32 inch when the brush "A" is pulled strongly by hand to the left. These distances of 1/16 inch and 3/32 inch can very easily be measured by means of a special gauge, as shown in Fig. 221. The nut "N" can then be locked by tightening the nut "O."

The spring "J," which controls the degree of compression reached in the main carbon piles U, U′, should then be adjusted. This spring should be compressed until the distance between the lever "G" and the washer "X" measures approximately 1⅜ inches. By locking the nuts H′ and H″ together the spring can be held in this position.

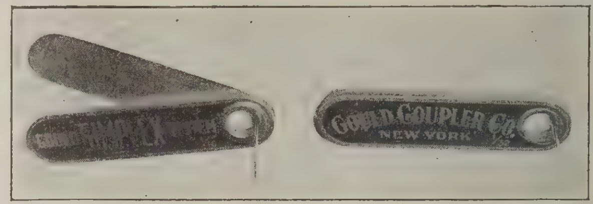


Fig. 221. Special Gage for Setting the Regulator.

Now allow the lever "M" to return to its lowest position against the stop "W" and by means of the cap screws K and K′, compress the main carbon piles U, U′ until the auxiliary carbon pile "T" at the bottom of the board is under full compression. This can best be determined by feeling of the carbons of the pile "T" and when it becomes difficult to slide one of these carbons vertically in the pile, the pile may be then considered tight. Even then, however, it may be possible to twist the whole carbon pile "T," as it is simply held between two pivot points, and this movement of the pile must not be confused with the vertically sliding of one of the discs.

The lever "M" will in most cases be caused to rise off the stop "W" when the piles "U" and "T" are fully compressed, but this is not absolutely necessary. It has been customary in the past to adjust the pressure on the carbon piles U, U′, by tightening up on the cap screws "K" and K′ until the pressure on the carbons causes the lever "M" to be lifted off the stop "W." This, however, will put an unnecessarily great strain on all the levers and lever pins of the regulator and will put more pressure on the carbons than is necessary. The main point is to tighten the cap screws K, K′ until the short circuiting carbon pile "T" is tight.

The equalizing lever "Y" should be kept as nearly vertical as possible by dividing the adjustment between the two screws K, K′. After these screws have been properly adjusted they should be locked in place by means of the lock nuts "L" and L′.

Adjusting the Multiplier.

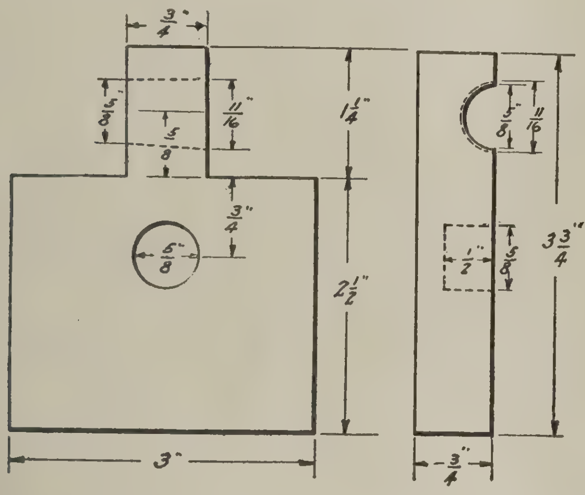
In adjusting the multiplier the stud "C" should be set so that the lever "Z" comes down to within approximately ½ inch from the magnet frame W′. Enough carbon discs should be placed in the carbon pile "V" to permit full compression of the pile by approximately ⅜ inch upward movement of the lever "Z," and at the same time allow the pile to be entirely released when the lever is in its lowest position. The lamp voltage may be raised or lowered by moving the balancing weights Q, Q′ to the left or right, respectively. Moving these weights to the left, will add to the weight of the plunger and require a higher voltage to lift them; moving them to the right, will decrease the effective weight of the plunger and allow a lower lamp voltage to raise the plunger. This adjustment covers a range of 2 volts on a 30-volt regulator, and 4 volts on a 60-volt regulator. Moving the weights from the center to the left end will raise the lamp voltage 1 volt and moving them from the center to the right end, will lower the lamp voltage 1 volt. If a further alteration of the lamp voltage is required, it may be accomplished by adding weights "R" or removing them from the dash pot piston "S." The lead weights sent out with the regulator will make an increase of approximately 1 volt for each weight, added to the piston, in the case of the 30-volt regulator, and nearly 2 volts for each weight added on a 60-volt regulator.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Prevent Corrosion of Battery Connector.

Trouble is often caused by acid creeping up under the lead terminals and corroding the wire between the connector and the insulation. We are using a crimper to shrink the lead onto the insulation at the neck of the terminal. This makes practically an acid proof joint between the lead and the rubber insulation.



Sketch and Dimensions of a Crimper for Making An Acid Proof Joint Between the Left Terminal and the Rubber Insulation.

The crimper is constructed of two pieces of steel notched at the bottom as shown in the accompanying sketch. The two halves are pressed together in an ordinary vise after the terminal has been inserted. A ⅝ in. hole is drilled ½ in. into the inner faces of both pieces, as shown in the sketch. A coil spring is inserted between the two halves which, when the crimper is removed from the vise, forces the jaws open and allows the terminal to be removed.

The hole into which the terminal is placed is tapered from ⅝ to $\frac{11}{16}$ in., making the neck of the terminal without forming a shoulder and is very uniform.

M. F. Hand (Santa Fe), Topeka, Kans.

Moulds for Applying Leads to Battery Posts.

Take a piece of either gas or steam pipe with the same inside diameter as the outside diameter of standard positive and negative post. Cut rings to height of the post desired above cover and taper it by use of mandrel to same taper as standard post. Center punch mark the bottom of each ring to designate same, and slot each ring to allow for the wire. Then place the rings over the post and twist piece of ball asbestos around bottom of ring. Now fill the ring with hot solder by use of a flame and insert the wire. When the metal has cooled remove the rings.

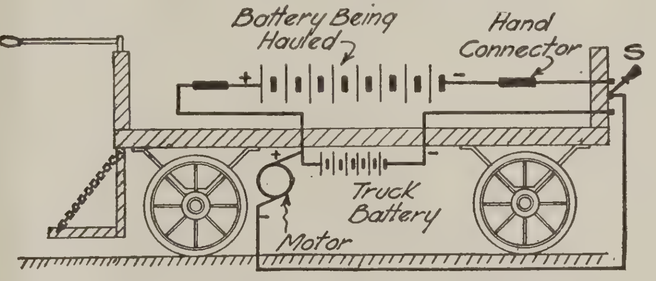
This makes the posts standard throughout the set of batteries and saves considerable time. The rings are very easily removed after being used once or twice.

Chas. W. T. Stuart, Philadelphia.

Operating Electric Truck by Batteries Being Hauled.

In order to save the batteries of an electric truck, which are usually of relatively small capacity as compared to car lighting batteries, it is often convenient to drive the truck from the batteries which are being hauled. The connections in the accompanying figure show how this may be done.

This scheme is exceptionally valuable at points where only one truck is available or no extra batteries are on hand when the operating set becomes exhausted, or it may be used merely as an emergency connection to be used in case the truck batteries fail.



Sketch Showing Wiring Connection for Operating an Electric Truck from Car Lighting Batteries Being Hauled.

All that is needed extra is a single pole double throw switch with two lengths of wire fitted with Westinghouse hand connectors for connecting to the battery being hauled.

Charles W. T. Stuart, Penn R. R.

Truing Car Lighting Armature.

It often happens that when a car lighting armature is set up in a lathe to turn the commutator, the pulley end center is found to be out of true. It takes some time to true up the center, and chances are that it will be out again when the armature comes in for another repair.

To save the time necessary to true up the centers, we have designed a rig which is made up as follows: Take a piece of steel ½ in. x 5 in. x 12 in. which may be tapered at the ends to reduce the weight. In the center of this piece of steel drill a hole just large enough so that it will slip over the commutator end of the shaft. In each end of this piece of steel drill a hole for a ½ in. bolt. Next make a wooden clamp to clamp on the end of the shaft and tighten with wing nuts.

This rig is used as follows: Slip the steel plate over the shaft and fasten the wooden clamp on the end. Next place the armature in the lathe between the center with the commutator end toward the head of the lathe, then press the plate up against the wooden clamp and pass ½ in. bolts through the ends of the plate and the face plate and draw up tight. Now place the steady rest under pulley end of the shaft and withdraw the tailstock center; everything is now ready for truing the commutator.

To avoid any danger of the wooden clamp sliding and allowing the armature to back off the center, we use a flat end center in the tailstock and bring this close to the end of the shaft.

Mr. C. B. Jennings,
Topeka, Kans.

Drills for Tapping.

Men who only occasionally have to drill holes to be tapped out are usually at a loss to know what size drill to use for a given tap.

For the convenience of our men, I made out the following table, stamped it on a brass plate and screwed it to the wall near the drill press:

Pipe Taps.

Pipe Size.	Tap Drill.	Body Drill.
1/8	11/32	7/16
1/4	15/32	19/32
3/8	19/32	3/4
1/2	11/16	7/8
3/4	29/32	1 1/16
1	1 9/64	1 7/16
1 1/4	1 1/2	1 3/4
1 1/2	1 23/32	2
2	2 3/16	2 13/32
2 1/2	2 5/8	2 15/16

Machine Screw Taps.

Screw.	Tap Drill.	Body Drill.
4-36	3/32-41	1/8 -33
6-32	7/64-33	9/64-28
8-32	9/64-28	11/64-17
10-24	5/32-23	13/64-6
12-24	11/64-15	15/64-1
14-20	3/16-10	1/4
16-18	13/64-4	9/32
20-18	17/64	11/32
1/4-20	13/64-9	17/64
5/16	1/4	21/64

Screw.	Tap Drill.
3/8 -16	19/64
7/16-14	11/32
1/2 -13	13/32
5/8 -11	1/2
3/4 -10	5/8
7/8 -9	3/4
1 -8	27/32
1 1/8 -7	15/16
1 1/4 -7	1 1/16

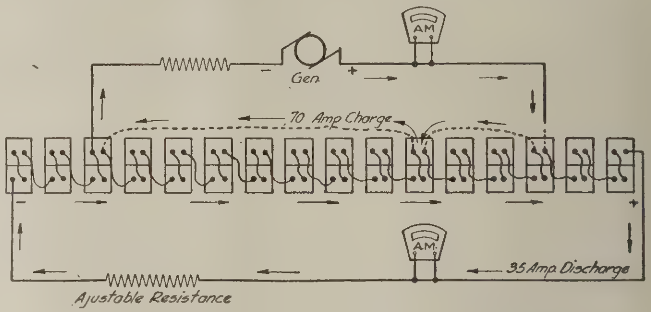
The first column gives the size of the tap and in case of the machine screws the number of threads per inch also. The second column gives the tap drill or size drill to use if you wish to tap out the hole. The third column gives the body drill or size drill to use if you wish the screw to slip through the hole.

Where the screw sizes are given in fractions of an inch, as ¼, $\frac{5}{16}$, etc., the body drill size is omitted as that would, of course, be one size larger than the screw.

C. B. Jennings,
Topeka, Kan.

Charging & Discharging a Battery at the Same Time.

While discharging a set of batteries the voltage of one or more cells may indicate that they are in a discharged condition, while that of the others may indicate that they are only one-half discharged. Instead of cutting out these dead cells and charging them separately, connections such as indicated in the accompanying sketch can be made so that the low cells can be placed on charge without interruption to the discharge of the rest of the battery. This will save much time if only a small proportion of the cells have to be charged in this way.

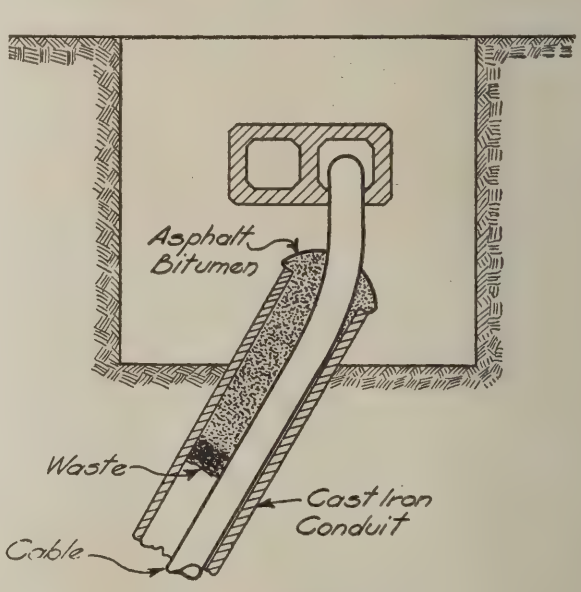


Battery Connections for Charging and Discharging.

Charles W. T. Stuart, Penn R. R.

Protecting Cables and Conduit from Moisture.

It very often happens that where a cable passes from an outlet box into an underground conduit that considerable difficulty is met with because of moisture collecting in the conduit and injuring the cable. This trouble was experienced with an installation in which the cable passes from a clay conduit into a cast iron conduit passing under a river to an electric swing bridge. Although all connections were maintained water tight, moist air left a collection of water in the cast iron conduit. This trouble was remedied as follows:



Water-tight Conduit Plug.

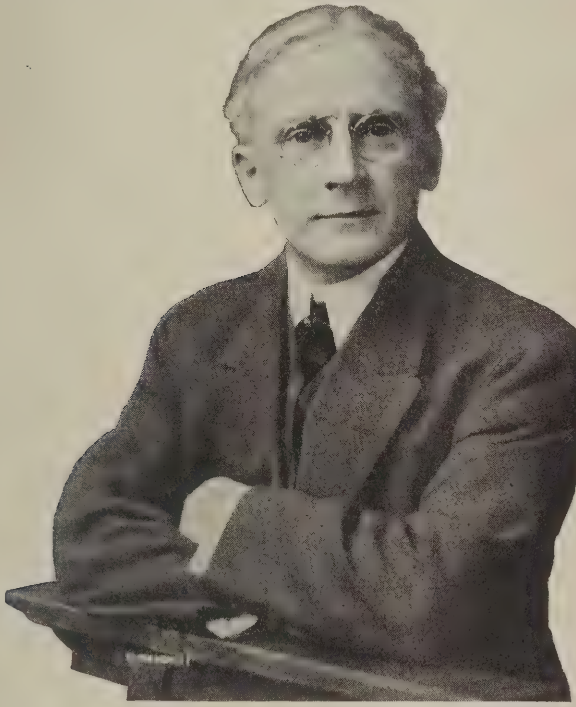
The space between the cable and the cast iron conduit where it enters the outlet box was plugged up with waste and asphalt bitumin was then poured in so as to seal this end of the conduit as shown in the sketch. This effectively prevented moist air from entering and all trouble from this source was eliminated.

J. G. Koppel, Elec. Supt. of Bridges.

General News Section

Bertram Smith Appointed Detroit Manager Edison Storage Battery Co.

Mr. Bertram Smith, well-known in the storage battery business for the past fifteen years, has been appointed manager of the Detroit office of the Edison Storage Battery Company. About a year and a half ago Mr. Smith joined the Edison interests as assistant manager of the Edison Storage Battery Supply Company of San Francisco, the distributor for the Edison Nickel-Iron-Alkaline Battery on the Pacific Coast. Directly previous to his connection with the Edison Company he was manager of the battery department in the Chicago Branch of the United States Light and Heating Company. He was formerly secretary and treasurer of the National Battery Company of Buffalo until its consolidation with the United States Light and Heating Company. In taking up his new duties in Detroit, therefore, he is returning to familiar territory. In order to better serve its customers in eastern Michigan as well as Ohio and adjoining territory the Edison Storage Battery Company recently moved its Cleveland office to Detroit where it has located in the new David Whitney building on Woodward avenue. The appointment of Mr. Smith as manager, together with the company's rapidly growing business in this section is expected to make the Detroit office one of the most important branches.


Bertram Smith.

The Cruise of the "Nomad."

It was a gay party that pulled away from the wharf of the Chicago Yacht Club on the beautiful afternoon of August 10th. Skipper G. H. Atkin, in his good ship "Nomad," by the grace of the "Weather God," saw to it that all had a most enjoyable time.

The day was perfect for a sail, the weather being fresh and fair and a breeze that would delight any sailor's heart or even a railroad man's, and as the ship plowed easily through the bounding billows Messrs. Beck and Wray, on a mandolin and guitar, gladdened the hearts of all on board with their sweet harmonies played to the time of the spanking waves. The rough water held no terror for the railroad men, as their experience on their own roadbeds has been all too good. But railroad men were not the only ones favored for as lake transportation cannot hide behind the rulings of the Interstate Commerce Commission, free passes were allowed to all on board.

The Crew of the Good Ship "Nomad."

The excursion remained within the confines of Illinois, but rumor has it that the buffet car was on the job. At 6 o'clock the dining car was cut off at the Chicago Yacht Club and all agree that lake air is a great appetizer.

The fortunate ones were G. H. Atkin, H. M. Beck and R. T. Milton of the E. S. B. Co., C. R. Gilman of the St. Paul, H. G. Myers and "Alex" Voigt, Santa Fe, "Bob" Pachaly, Rock Island; J. H. Burcham, C. & E. I., and Messrs. O. R. Shorthall and Phinney of the Northwestern, and Edward Wray of the Railway Electrical Engineer.

With the Manufacturers

Test on Pole Guy Anchors at Cleveland, Ohio.

The Faultless Anchor Company of Fostoria, Ohio, made general announcements that a test of their anchors would be made in Cleveland, August 9th. These tests were carried over to the 10th on account of the necessity of securing heavier pulling tackle to thoroughly test the larger anchors.

The test was witnessed by a large number of representative electrical men, including Messrs. McCarty, superintendent of construction, and Spangler, inspector of pole line construction, of the Cleveland Bell Telephone Company, and Messrs. Sharp, superintendent of construction, and Richardson, pole line supervisor, of the Western Union Telegraph Company; Mr. Burgess, superintendent of the overhead construction of the Cleveland Illuminating Company, and Mr. Pearson, foreman of construction of the Ohio State Telephone Company.

The object of the test was to obtain data bearing upon the holding strain of mechanical anchors, and second, to determine the ultimate or necessary strain required to break or pull the anchor from the ground.

The load was applied to the anchors by connecting them through a dynamometer with a double set of large blocks and a heavy duty chain fall to a heavily guyed pole of normal height. A substantial initial strain was first applied and a mark made on the anchor rod to indicate its initial position. The creeping of the rod was measured from this initial mark. The load was added in increments of from 500 to 1,500 pounds. Measurements for creep were made between each loading. An interval of five minutes without pull was allowed between each load.

The results of these Faultless anchors were as follows:

Test No. 1—½ inch rod, 2 blade, 16 inch spread anchor, held without creep at 5,500 pounds. This anchor made a very remarkable showing in that the next load added pulled its rod apart at 6,600 pounds.

Test No. 2—⅝ inch rod, 2 blade, 18 inch spread anchor, held without creep at 4,800 pounds, when one blade broke due to a flaw in casting. The capacity of this anchor is said to be about 9,000 pounds.

Test No. 3—¾ inch rod, 3 blade, 18 inch spread anchor, held without creep at 12,800 pounds. The blades of this anchor bent down at 13,200 pounds.

Test No. 4—1 inch rod, 4 blade, 24 inch spread anchor, blades bent down at 15,200 pounds without creep. This anchor is a late addition to the line, intended to hold without creep at 16,000 pounds, for dead end and cable strain service. This is said to be the first test of this very large anchor and proved quite conclusively that more metal is required in the fins. This change is being made.

The basic principle of this new Faultless ancor is considerably different from that of other makes on the market. It depends primarily upon virgin or undisturbed earth to hold it in the ground. The very large holding surface which it presents to undisturbed soil eliminates tendency to creep. This anchor may be installed in virgin soil in a very short time.

Mine Locomotives.

The increasing output of many mines has rendered it necessary to equip with locomotives of relatively large capacity, capable of handling heavy trips over steep grades and for long hauls. For this class of service there have been built a number of 3-motor, 15 and 20-ton locomotives. The 20-ton unit combines some unusual features in design and construction. The body is made of rolled steel, each side frame being cut from a solid rolled steel slab, while steel slabs in conjunction with steel channels are used for the end frames. The three driving motors are each rated at 85 hp. and are of the split frame type. These particular locomotives were built for 42-in. gauge but the same construction and capacity can be utilized for a minimum of 36-in. gauge.

There has been a definite increased demand for the storage battery type of locomotive for gathering work, as it has been demonstrated that in this service each locomotive will effectively displace at least two or three mules. Heavy units are not as a rule required, and the locomotives of this class so far provided have been rated at from 3 to 7 tons. Most of these are of the straight storage battery type; but a limited number have, in addition, been equipped so that they can operate from a trolley wire when in the main headings of a mine. The advantages of this arrangement are obvious in that by means of a small self-contained motor-generator set, the battery may be automatically charged while the locomotive is running on the trolley. When the locomotive is working in the rooms gathering the cars, a varying percentage of the battery charge will be consumed, but as soon as the locomotive is again operated on the trolley, these losses are automatically compensated for. With this dual system of operation, the battery need never be entirely discharged; and if space limitations are severe, it permits the use of a smaller battery than would otherwise be necessary. A General Electric machine of this type has been in operation in a West Virginia mine for a period of about six months. It runs on a 42-in. gauge track and its overall height does not exceed 30 in.

Electric Arc Welding.

A most interesting and valuable booklet entitled Electric Arc Welding, has been prepared by the Lincoln Electric Company of Cleveland, Ohio, which gives the underlying principles of arc welding practice. The author treats with the most fundamental principles of welding and explains how the electric arc may be used for this purpose. The advantages of the electric arc welding are discussed at length and considerable space is devoted to the methods which may be used to weld different kinds of metals by this method. A large number of interesting illustrations show how special jobs have been completed. It is shown how the electric arc may be used in production such as welding castings to other metals, welding tank seams, etc. Defective castings are also easily repaired and broken parts are mended by this method.

The types of machines which are used on these various jobs are described and questions which are often asked about arc welding are answered in a special section.

Direct-Reading Device for Computing Characteristics of Vacuum Tungsten Lamps.

It is well known that a change in the voltage applied to the terminals of an incandescent lamp changes the candlepower, current, and in consequence the wattage (watts-volts X amperes) and the watts per candle. If these changes are followed from point to point, relations among the variables may be found and plotted as characteristic curves. The equations of these characteristic curves for tungsten lamps have been found by the Bureau of Standards, Department of Commerce, and a special application of these equations has been made in a device which gives a solution of problems involving voltage, candlepower, and watts per candle.

In this device the volt scale is movable, and, by setting it to the other scales at a point corresponding to the observed watts per candle, values of per cent candlepower and of actual watts per candle may be read directly from the proper scales, or the converse problems may be solved. Use of this device results in a decided saving of time when compared with other methods of characteristic evaluation. In connection with the device are given tables of values used in its construction and practical examples illustrating scale settings.

The report upon this subject, just issued, has been designated Scientific Paper No. 253 and copies may be obtained without charge upon application to the Bureau of Standards, Washington, D. C.

Railroads to Increase Their Dispatching Facilities.

The Illinois Central and Atlanta and West Point Railroads are planning to add additional equipment to their train dispatching facilities. The plans of the Illinois Central call for ten complete stations which will be cut in, in addition to the fifty which they have had in service since January.

The plans of the Atlanta and West Point Railroad call for 13 complete stations which will be added to the 30 the company has had in operation since early Fall. The equipment in both cases will be furnished by the Western Electric Company.

Additions to Condulet Line.

Condulets, Bulletin No. 1000C is the title of a 6x9-inch, 32-page supplement to Condulets, Catalog No. 1000 that has just been issued by the Crouse-Hinds Company. This bulletin illustrates, describes and lists many new types and styles of Condulets and Condulet accessories, besides numerous additional sizes of older forms of Condulets. It is a book that should be exceedingly valuable to those who are at all interested in Conduit installations.

S. K. F. Ball Bearing Co. Notes.

The S. K. F. Ball Bearing Company have been obliged to greatly increase their office space in the Hudson Terminal Building. Within the last four months they have about doubled their offices, so that they now occupy a full wing on the 6th floor of the Hudson Terminal Building, 50 Church St., New York.

This company is the only ball bearing company importing bearings from Europe that has not been interfered with by the war. Sweden, being a neutral country, is enabled to send large and regular shipments via Norway and Denmark without entering the war zone.

These Swedish imported ball bearings are now very much in demand on account of the high grade of the material and workmanship. The bearings are made in Gothenburg in a model factory employing 3,000 hands, engaged exclusively in the manufacture of S. K. F. Ball Bearings.

New Portland Quarters for the Western Electric Company.

Expansive business growth has caused the Western Electric Company to give up its old quarters at Portland, Oregon. Since 1910 the Company has been located on Fifth Street, but has now moved into a new two-story brick and concrete building which has been made ready for them at East Ash and Union Streets. The building with efficiently designed shipping, receiving and warehousing facilities is one of the most modern of its kind in the Northwest.

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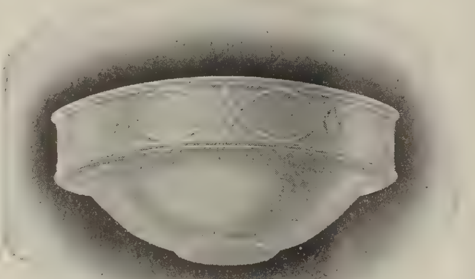

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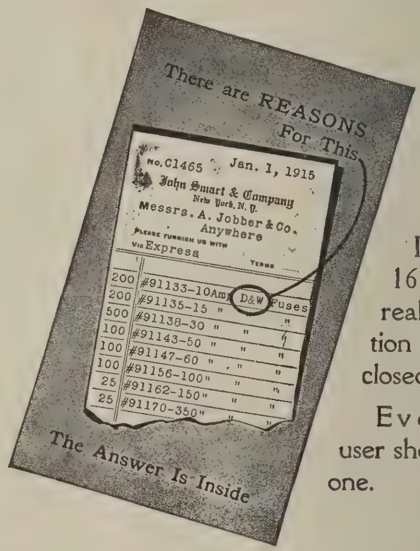

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Messrs. A. Jobber & Co.
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RAILWAY
ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.
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STATEMENT OF OWNERSHIP

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Edward Wray,
Publisher.

Sworn to and subscribed before me this *Sixth* day of *October*, 1915.
Henry E. Gerry.
[SEAL.]
Notary Public.
(My commission expires April 6, 1916.)

Railway Electrical Engineer Under New Management

Electrical men of the steam railroads, as well as mechanical officials concerned with electrical equipment in railroad operation, will be interested in learning of the recent purchase of the Railway Electrical Engineer by the Simmons-Boardman Publishing Company, publishers of the Railway Age Gazette, the Signal Engineer and the Railway Age Gazette, Mechanical Edition.

This change of ownership and management will not mean any lessening of the activities of the Railway Electrical Engineer in this very important field. It will be continued as a separate publication, and, with the greatly increased facilities afforded by the large technical staff of the Simmons-Boardman Publishing Company's organization, together with the present staff of the Railway Electrical Engineer, the ability of this journal to serve its particular field will be greatly increased.

Beginning with the November issue, the Railway Electrical Engineer will be published by its new owner in New York. Mr. Edward Wray, former publisher of the Railway Electrical Engineer, will be located at the New York office of this company and will continue his connection with the paper as business manager.

Although this publication will no longer carry the title "Official Journal" of the Association of Railway Electrical Engineers, its activities in the interests of this association will be in no way lessened. In fact, under its new management the Railway Electrical Engineer will be able to serve this association more effectively than ever before, and the new management sincerely hopes to receive the same earnest co-operation on the part of the members of the association, both individually and collectively, as has been accorded to the management which now relinquishes control.

All of the subjects previously covered in the Railway Electrical Engineer will be dealt with even more fully in the future, and this will be especially true of the maintenance of heavy electric traction equipment, and of electric locomotives and other features pertaining to electrification of steam railways.

There is little doubt in the mind of any far-seeing railroad officer that the day of extensive steam railroad electrification is not far distant. Accordingly, the contents of a journal devoted to the problems of men concerned with the uses of electricity on railroads and with the care and operation of electric equipment should excite unusual interest on the part of higher railroad officials as well as on the part of men directly engaged in electrical work.

Standardization of Traveling Crane Motors

The work of the committee on Standardization of Traveling Crane Motors has brought to light a situation that seems to have been somewhat neglected in the past. From a large amount of information furnished by practically all of the big railroads in the country, it has been determined that there is a rather chaotic situation existing in crane motor equipment of railroad repair shops.

This committee shows that between the capacities of 1 ton to 150 tons there are 25 different crane sizes employed—a situation which only the extreme age of some of the equipment can justify or explain. Certainly the requirements of all modern shops can be taken care of by a considerably smaller number of crane sizes and it is interesting to note that the committee has reduced this number from 25 to 6.

This is the first important step in the standardization of crane motors. The next is that of establishing some rational operating speeds as standard. This, of course, involves the personal equation of the railroad officials assigned the work of laying out a new shop, but judging from the wide divergence of operating crane speeds performing the same function, altogether too much of the "personal equation" has entered into the problem heretofore. It is interesting to note the uniformity of the manufacturers' recommendations as outlined by the committee.

Having crane sizes reduced to a minimum and operating speeds standardized, standard motor sizes follow automatically, and with the earnest co-operation of both crane and motor manufacturers, which the movement has already received, it should be possible to standardize on overall motor outline, motor pedestal templates, motor shafts and key-ways, so that in case of emergency a standard motor of the proper size may be installed temporarily in connection with any type of crane. The successful working out of this big problem will perform a great service in the interests of economy of operation, as well as first cost and maintenance of shop traveling cranes and at the same time will relieve railroad companies from carrying a vast assortment of spare crane motor sizes and makes in order to guard against break downs.

Eighth Annual Convention A. R. E. E.

October 18-22, Hotel La Salle, Chicago

The Association of Railway Electrical Engineers assumes no responsibility for the individual views of its members on the various topics and disavows any action taken on the various subjects except such action as is taken in due course and accordance with the constitution.

J. A. Andreucetti, Sec.-Treas. Association Railway Electrical Engineers.

Committee on Standards

A joint meeting of the members of the A. R. E. E. Committee on Standards and the Train Lighting Committee of the M. C. B. Association was held in New York City, February 18 and 19, 1915. The result of this joint meeting was submitted to the members of the M. C. B. on letter ballot. In view of the fact that the results of this letter ballot were not at hand when this report was made out, it was thought best by your chairman not to call a meeting until results of ballot were known.

The joint committee recommended that—First: Changes be made in regard to placing fuses as close as possible to the generator. Second: The dimensions of battery boxes be changed by reducing the distance from front to back three inches. The 1914 recommendations called for a depth of twenty-eight inches. It is now recommended to make the depth twenty-five inches. Third: That on all new or remodeled generators for car lighting having armature shafts 1⅝ ins. or over in diameter be provided with a taper pulley fit of 1½ ins. in 12 ins. Fourth: That on armature shafts less than 1⅝ ins. diameter the pulley fit be ¾ ins. in 12 ins. Fifth: That on ball bearing or roller bearing generators the bearing size known as No. 412 be used. Sixth: That all wiring in cars for electric lighting to run in conduit. Seventh: That the generator pulley need not be perforated.

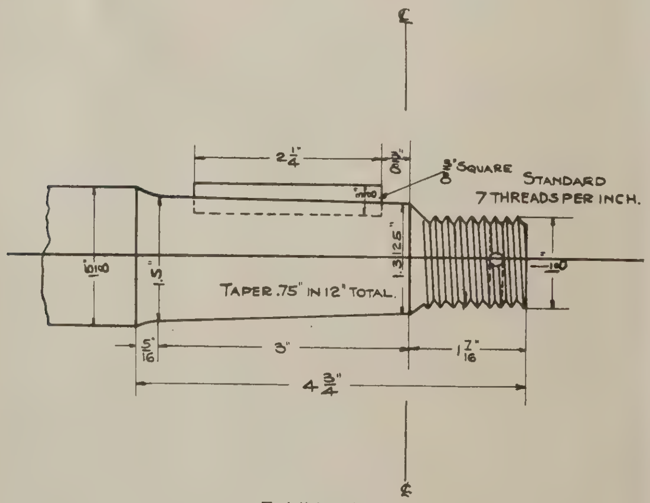

Exhibit "D"

For the information of our members, the Chairman of your committee wishes to call to your attention that all the members of the M. C. B. Train Lighting Committee were not favorable to the recommendation in regard to the 1½-in. taper fit, or the location of the web in the dynamo pulley.

The recommendation of the A. R. E. E. Committee on Standards, October, 1913, submitting a taper fit of ¾ in. in 12, page 124. Armature pulley 8 ins. diameter, page 125, and 11-in. pulley on page 126; both pulleys having ¾ in. in 12 taper fit, were adopted by the association. There was also submitted a design for pulley and pulley fit, having 1½ in. in 12 taper fit, the same as originally submitted at the semi-annual convention, 1912, which is approximately the same as was submitted to the M. C. B. for letter ballot.

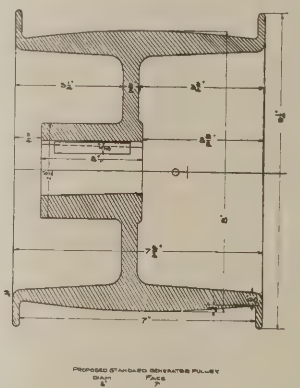

Exhibit "E"

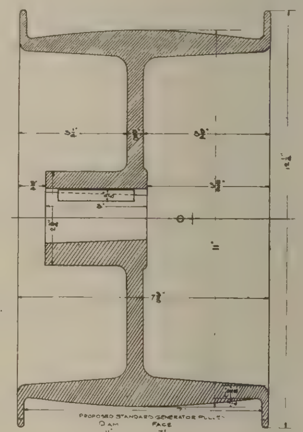

Exhibit "F"

It is very evident our members in voting on these recommendations did not read carefully the last two lines on page 126, 1914 Proceedings, which were as follows:

"Exhibits D, E, F and G are presented for discussion as to adopting *one of them* for standard armature shaft fit and one for generator pulley fit."

The members voted to accept all of them instead of only one.

In order to correct this error, your committee again presented to the association their recommendations. The committee report was accepted with instructions to hold a joint meeting with the M. C. B. Train Lighting Committee, which was held in New York, February 18 and 19, 1915.

Under date of March 20, 1914, the chairman of your committee received a copy of a letter sent to the chairman of the M. C. B. Committee from Mr. Bliss protesting against the 1½-in. taper fit, and giving reasons for the ¾-in. taper fit.

Under date of November 2, 1914, your chairman received a letter from Mr. Quinn of the N. & W. R. R., who is also a member of both committees, regretting the fact that the convention has adopted the 1½-in. taper fit.

Under date of February 25, 1915, your chairman received a letter from Mr. L. R. Pomeroy, of the U. S. Co., who is an authority on mechanical matters, in which he stated that the taper fits adopted by the following firms or corporations is as stated below:

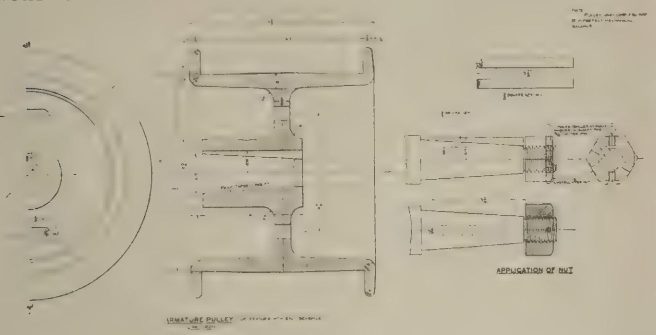

Exhibit "G"

American Railway Elect. Association, General Electric Company and eWstinghouse Company, 1¼ ins. in 12 ins.

American Locomotive Co., ¾ in. in 12 ins.

Baldwin Loco. Works, .6 in. in 12 ins.

P. R. R. for heat treated piston rods, ¾ in. in 12 ins.

Great Northern Ry., for heat treated piston rods, ½ in. in 12 ins.

N. Y. N. H. & H., throttle stem, ¾ in. in 12 ins.

N. Y. N. H. & H., motion work in double shear, ¾ in. in 12 ins.

N. Y. N. H. & H., motion work in single shear, ¾ in. in 12 ins.

Drill Shanks—

Morse, ⅝ in. in 12 ins.

B. & S., ½ in. in 12 ins.

Jones & Reed, .6 in. in 12 ins.

Sellers, ¾ in. in 12 ins.

1½-in. taper in 12 ins. is an orphan.

Under date of April 8, 1914, Mr. Quinn, of the N. & W. R. R., called the attention of the chairman of the M. C. B. Committee to the fact that we might consistently consider the taper fits which are standard with the machine tool builders, confirming the taper fits of Brown and Sharp, also Morse & Co., for drill shanks. Mr. Quinn's letter was not called to the attention of the other members of the M. C. B. committee.

Under date of April 12, the chairman of your committee wrote a letter to the chairman of the M. C. B. Committee, requesting consideration of the change in location of web of generator pulley, so that the proposed pulley could be made interchangeable between ball and sleeve bearing generators. The chairman also sent drawings for sleeve bearing generators having a taper fit of ¾ in. in 12 ins., to conform with the proposed M. C. B. recommendations for sleeve bearing generators—which were not included as a part of the report of the M. C. B. committee.

The chairman of your committee has gone into this subject very thoroughly and would like to bring before the members of our association the fact that all armature shafts 1½ ins. or larger in diameter, at inside end of pulley fit, can be made to fit a ¾ in. in 12 ins., except the shaft pulley fit which is recommended to the M. C. B. As this proposed shaft is too small in diameter at end, and is of such a taper, a much greater strain is brought against the key.

It is recommended by a member of the committee that the question of adoption of Exhibit G, Proceedings of 1913, page 126, be considered.

Respectfully submitted,
D. J. Cartwright, Lehigh Valley R. R., Chairman.
H. C. Meloy, New York Central (Lines West).
J. H. Davis, B. & O. R. R.
C. H. Quinn, Norfolk & Western Ry.
E. W. Jansen, Illinois Central Ry.
Ernest Lunn, Pullman Co.

Unfavorable Report on Chicago Electrification

The committee on smoke abatement and electrification of railway terminals of the Chicago Association of Commerce has decided that the electrification of Chicago's terminals is impractical and impossible to finance.

The proposed electrified zone contains more than 4,500 miles of track, over half of which is within the city limits. At least 1600 electric locomotives at $40,000 apiece will be required at 1,500,000 k.w. power house capacity, costing $100.00 per k.w.

Committee on Reciprocal Relations

Your committee has had no questions arise during the year in which it has been necessary to take the initiative in co-operating with the work of other associations. The Association is, however, in certain of its undertakings keeping in close touch with the work of other societies.

The Committee on Standards for Train Lighting is working closely with the Committee on Train Lighting Equipment of the Master Car Builders' Association, several of the members being on both committees. The Committee on Illumination has been in communication with the Committee on Yards and Terminals of the American Railway Engineering Association, and is arranging to furnish that committee with the results of the investigation of yard lighting now being made by our association. The Illuminating Engineering Society has suggested the holding of a joint meeting to discuss matters pertaining to railway lighting problems, but inasmuch as our association does not hold frequent meetings (as is done by the Illuminating Engineering Society) such plan has not been feasible.

The Committee on Wire Crossings was in communication with the National Joint Committee on Overhead and Underground Line Construction, and endeavored to obtain representation on the committee, either officially or unofficially, but was unable to do so.

Your committee believes that the greatest value to be gained by this association in co-operation with others is in matters pertaining to recommendations for standards, specifications, etc., and in this connection it is the intention to keep in touch with the various associations in reference to such matters that are of mutual interest.

Respectfully submitted,
Committee on Reciprocal Relations,
L. S. Billau, B. & O. R. R., Chairman.
Jos. A. Andreucetti, C. & N. W. Ry.
J. R. Sloan, Pennsylvania R. R.

Committee on Loose Leaf Binders

Your committee has investigated the different types of loose leaf binders on the market, and has selected the one that in their judgment is the best for the purpose, it possessing the following features that were considered desirable:

(a) Minimum space required for binding.
(b) Flat opening.
(c) Will hold securely a few sheets or a greater number up to the full capacity of binder.
(d) Ability to readily insert or remove a sheet at any point, without the necessity of disturbing other sheets.

The committee have also been compiling the information to be inserted in these binders—this necessitates a careful perusal of the proceedings. This is a long and laborious work, and the committee requests that it be given additional time to complete this work.

Respectfully submitted,
J. R. Sloan, Chairman.
J. L. Minick.
T. V. Buckwalter.

Committee on Wire Crossing Specifications

Your committee appointed for considering wire crossings specifications has endeavored to obtain representation on the National Joint Committee on Overhead and Underground Line Construction, this representation being refused on the ground that the railroad interests are now represented on this committee by the following associations:

Association of Railway Telegraph Superintendents.
The Railway Signal Association.
The American Railway Engineering Association.
American Railway Association.

And, therefore, the railway companies' interests were being properly looked after, and as the committee was already very large, representation by our Association was refused.

In view of the above facts, your committee would suggest that the committee be continued with instructions to keep in touch with the wire crossings specification situation and report to the Association at the proper time the specification as finally determined upon by the above mentioned National Joint Committee.

Respectfully submitted,
J. R. Sloan, Chairman.
S. M. Viele.

Committee on Data and Information

Your committee has endeavored to continue the work of compiling statistics of electrical equipment in use on steam railroads with a view to comparing the statistics of various years to obtain the general trend of the increase or decrease in the use of any particular type of equipment. As in previous years, your committee has experienced considerable difficulty in getting information from the railroads and it will be noted that there were 20 roads reported in 1914 who did not report this year and 18 roads reported in 1912 who did not report in 1914 or 1915, in spite of repeated requests for this information. This gives an idea of the difficulties of the work of this committee and also of the limitations as to the reliability of the information published as final totals. There is no doubt but that if the exact

RAILROAD	CAR LIGHTING DATA										HEAD END SYSTEM			AXLE GEN. SYSTEM			CAR LIGHTING COSTS Per 1000 Car Mile Basis						Car Lighting Belts		Car Lighting Generator Bearings				Water for Batteries Div. P. Usng				INDUSTRIAL TRUCKS				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
	Total Pass. Cars Operated	Total Cars Electric Lighted, owned by R. R. Co.	Cars Electric Lighted, Operated by Railroad Co.	Number Cells Lead Battery	Number Cells Nickel Iron Battery	Gas Lighted Cars	Oil Lighted Cars	Combination with Electric	Straight Storage Cars, 60 Volt	Straight Storage Cars, 30 Volt	Cars with Turbine Set	Cars with Reciprocating Engine Set	Cars with Battery used in head End Trains	Number of Cars, 60 Volts	Number of cars, 30 Volts	Number of Cars, 24 Volts	Coaches (All Classes)	Diners (All Classes)	Baggage Cars (Including Combination)	Mail Cars	Pullmans	Business Cars	Method of Computing Mileage	Average Belt Mileage	Number Generators	Number Ball Bearing Failures	Number Plain Bearing Generators	Number Plain Bearing Failures	Distilled Water Used	Tap Water Used	Pipe Condensation Used	Filtered Water Used	Baggage Handling	Freight House	Battery and Commissary	Electric Tractors	Shop Trucks
Atlantic Coast Lines	688	60	60	464	975	295	333	4	....	....	....	....	....	....	60	....		No	Rec	ord			A	6729	8	X	20	X	4	0	0	0	0	2	0	0	0
Baltimore & Ohio	1256	172	180	3326	1571	623	461	5	56	0	0	0	0	28	98	0	1.76	5.03	0	0	3*34	....	B	15,300	100	8	24	....	All	..	..	..	....	....	....	..	..
Canadian Northern	838	184	184	4600	0	343	310	0	0	0	0	0	0	0	3	181	....	....	....	....	....	....	....	....	....	....	....	....	All	0	0	0	....	....	....	..	..
Canadian Pacific	2781	390	390	7944	1558	1985	405	36	0	0	0	0	0	0	0	390	....	....	....	....	....	....	B	44,000	390	0	....	....	0	4	4	0	7	20	....	0	0
Chicago & Alton	208	61	....	1104	0	119	28	34	10	4	0	0	0	9	26	0	....	....	....	....	....	....	....	....	9	0	26	0	0	1	0	0	....	....	....	..	..
Chicago & Western Indiana	30	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	..	1	0	0	0	0
C. B. & Q.	1302	759	859	....	....	40	491	595	....	....	52	0	100	11	....	....	X	....	....	....	....	....	X	....	x	....	....	....	0	6	0	0	0	19	....	..	1
C. M. & St. P.	1646	....	....	....	....	16	623	896	9	....	57	11	199	15	2..	....	....	Ave	r.	.92	....	....	B	33,000	4	....	12	....	1	2	..	..	....	....	....	..	..
Buffalo, Roch. & Pitts.	127	49	53	832	0	60	18	2	0	0	0	0	0	1	51	0	X	....	....	....	....	....	X	....	0	0	49	0	0	0	3	0	0	0	0	0	0
C. C. C. & St. L.	621	156	156	2912	25	286	181	3	....	1	0	0	0	24	132	....	....	....	....	....	....	....	....	....	....	....	....	....	5	0	0	0	....	....	....	..	..
Delaware & Hudson	466	5	5	64	25	170	221	4	0	0	0	0	0	4	1	0	X	....	....	....	....	....	X	....	1	....	4	....	....	..	..	..	0	0	0	0	0
Del. Lack. & West.	903	202	202	3296	50	509	180	7	....	....	0	0	0	....	202	....	8.90	2080	....	....	1407	....	B	3800	142	1	60	5	1	1	0	0	3	14	....	..	..
Denver & Rio Grande	416	54	54	848	50	182	176	8	0	0	0	0	0	1	53	0	X	....	....	....	....	....	A	6500	4	0	50	2	1	1	0	0	0	0	0	0	0
Ill. Central	1301	260	267	1200	4675	517	326	....	....	5	0	0	0	....	260	....	—	Ave	rage	—	2.15	....	B	24,000	6	0	254	6	8	1	1	0	1	4	....	..	1
Kan. City Southern	....	3	....	96	....	....	....	....	2	1	0	0	0	2	1	....	....	....	....	....	....	....	....	....	0	0	0	0	1	0	0	0	....	....	....	..	..
Louisville & Nashville	672	153	153	2032	656	23	496	0	0	2	0	0	0	0	151	0	X						X	....	41	4	112	....	12	0	0	0	....	....	....	..	..
Michigan Central	568	149	149	3008	0	229	181	3	0	0	0	0	0	8	141	0	....	....	....	....	....	....	B	18,000	95	1	59	....	1	3	0	0	....	....	....	..	..
M. St. P. & S. S. M.	464	126	126	2112	0	49	276	0	0	0	0	0	0	0	126	0	....	....	....	....	....	....	B	35,000	17	....	110	17	2	4	0	0	0	0	1	0	0
M. K. C. & Tex.	515	22	22	208	0	247	237	9	0	0	0	0	0	1	21	0	....	....	....	....	....	....	....	....	0	0	22	1	1	3	0	0	....	....	....	..	..
N. Y., Chi. & St. L.	....	10	10	22	....	....	....	....	....	....	0	0	0	2	8	....	....	....	....	....	....	....	A	10,000	0	0	2	0	1	0	0	..	....	....	....	..	..
N. Y. Central Lines East	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	..	....	....	....	..	..
N. Y., Ont. & Western	225	13	13	0	325	164	49	1	0	0	0	0	0	0	13	0	....	....	....	....	....	....	B	25,290	13	0	0	0	All	0	0	0	0	0	0	0	0
Northern Pacific	846	335	530	2000	2200	460	116	254	20	0	39	9	68	35	3	0	3.00	7.00	2.50	2.00	4.00	3.50	B	30,000	19	0	19	0	3	0	0	0	0	0	0	0	1
Oregon Short Line	307	126	126	128	675	172	8	124	0	0	6	0	8	....	....	....	....	....	....	....	....	....	....	....	15	1	2	0	3	0	0	0	6	0	0	0	0
Pitts. & Lake Erie	135	33	5	576	0	95	3	4	0	0	0	0	0	1	34	0	1.84	3.04	1.93	....	....	1000	B	22,000	34	0	1	1	1	0	0	0	3	6	....	..	..
Southern Ry.	1179	258	516	5290	50	....	....	....	0	0	0	0	0	0	258	0	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	..	....	....	....	..	..
Texas & Pacific	237	14	14	160	125	190	33	4	0	0	0	0	0	0	14	0	....	....	....	....	....	....	X	....	0	0	14	2	1	0	1	0	0	0	0	0	0
Transcontinental	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	..	....	....	....	..	..
Vandalia	....	53	....	944	0	0	0	0	43	0	0	0	0	10	0	0	....	....	....	....	....	....	B	....	7	0	3	0	2	0	0	0	0	0	0	0	0
Western Maryland	150	27	27	592	0	46	77	0	0	0	0	0	0	0	27	0	X	....	....	....	....	....	X	....	0	....	27	....	4	0	0	0	0	0	0	0	0
Western Pacific	61	....	55	880	....	5	1	....	....	....	0	0	0	0	55	0	X	....	....	....	....	....	X	....	0	....	55	....	1	0	0	0	0	0	0	0	0
Wheeling & Lake Erie	84	7	6	48	125	52	26	3	0	2	0	0	0	0	4	0	X	....	....	....	....	....	A	12,000	4	....	0	....	All	0	0	0	0	0	0	0	1
A. T. & S. F.	2074	617	917	115677	64	634	523	363	0	0	0	0	0	0	617	0	1.22	1.56	....	....	1.35	2.86	B	75,000	334	5	583	11	....	..	..	..	....	....	....	..	..
C. & N. W. Ry.	1785	305	305	3170	25	1032	651	262	0	0	21	5	41	16	74	0	1.25	4.00	0.25	....	3.75	....	B	20,000	0	....	90	....	0	2	0	0	0	0	0	0	2
C. H. & D. Ry.	184	20	21	268	....	40	107	16	....	....	0	0	0	1	20	0	X	X	X	X	X	X	X	X	3	0	18	0	0	1	0	0	....	....	....	..	..
El Paso & S. W. Ry.	71	....	19	416	0	32	9	7	0	0	0	0	0	1	25	0	X	X	X	X	X	X	X	X	12	0	14	5	2	0	0	0	0	0	0	0	0
Lake Erie & W. Ry.	67	4	4	64	....	38	25	....	....	4	0	0	0	0	4	0	....	....	....	....	....	....	....	....	3	0	1	0	1	0	0	0	....	....	....	..	..
Lehigh Valley Ry.	653	395	395	6208	125	73	69	0	0	....	0	0	0	0	389	0	....	....	....	....	....	....	B	24,000	154	1	235	3	3	3	0	0	....	50	....	..	..
Monon	117	23	23	416	0	61	34	2	2	0	0	0	0	0	22	0	....	....	....	....	....	....	X	8000	0	0	21	....	0	0	0	0	0	0	0	0	0
Penn. (Lines West)	1317	714	714	23,990	108	5	598	0	637	0	0	0	0	74	3	0	....	....	....	....	....	....	....	....	29	0	22	0	13	0	0	0	0	0	0	0	0
Totals Reported	25,394	5859	6560	97,927	13,407	7361	7272	2647	779	19	175	25	415	92	2908	571							av	23,200	1652	21	1909	53	73	32	9	0	21	109	1	0	6
20 Roads as Reported 1914	18,050	11,107	....	184,540	22,798	8,242	5026	1568	1664	167	98	13	190	140	8194	6													175	22	8	1	157	23	13	1	42
18 Roads Reported 1912	....	1827	....	24,680	448	....	....	....	299	....	....	....	....	....	1128	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	..	....	....	....	..	..
Grand Totals	43,444	18,793	....	307,147	36,653	15,603	12,298	4215	2742	186	273	38	605		13,039		....	....	....	....	....	....	....	....	....	....	....	....	248	54	17	1	178	132	14	1	48

Notations.—X—means No Record Kept.
A—Separate account for each Belt.
B—Total mileage divided by total Belts used.

RAILROAD	Mtr Crs			LOCOMOTIVE HEAD LIGHTS									
	38	39	40	41	42	43	44	45	46	47	48	49	50
							Maintenance of Arc Headlights						
	Straight Gasoline Cars	Gas-Electric Cars	Storage Battery Cars	110-Volt Arc	60-Volt Arc	30-Volt Arc	Labor Per Equipment Per Month	For Material Per Equipment Per Month	Total Cost Per Equipment Per Month	60-Volt Incandescent	30-Volt Incandescent	6-Volt Incandescent	Total Number of Locomotives
Atlantic Coast Lines	0	0	0	75	0	429	x	x	x	0	73	0	813
Baltimore & Ohio	0	0	0	*	0	120	3.63	1.59	5.22	0	3	4	....
Canadian Northern	0	1	0	....	....	300	....	....	....	....	....	....	....
Canadian Pacific	4	....	....	....	....	1379	....	....	....	....	2	....	....
Chicago & Alton	....	....	....	0	0	262	.60	....	....	0	262	....	327
Chicago & Western Indiana	0	0	0	0	0	0	....	....	....	0	0	0	....
C. B. & Q.	0	0	0	0	0	1179	....	....	....	18	....	....	1735
C. M. & St. P.	1	7	0	....	....	1636	4.57	1.94	6.45	....	....	....	....
Buffalo, Roch. & Pitts.	1	1	0	0	0	41	.35	.64	4062	0	1	0	365
C. C. C. & St. L.	....	....	....	....	....	64	3.00	12.6	15.6	0	0	0	847
Delaware & Hudson	0	1	0	0	0	0	0	0	0	0	0	0	0
Del. Lack. & West.	....	....	....	....	....	....	....	....	....	....	....	....	....
Denver & Rio Grande	0	0	0	0	0	365	8.00	.57	8.57	0	0	0	....
Ill. Central	2	4	....	....	2	261	....	....	....	....	9	....	1665
Kan. City Southern	....	....	....	....	....	....	....	....	....	....	195	....	....
Louisville & Nashville	0	0	0	0	0	156	4.26	1.70	5.96	0	0	0	0
Michigan Central	0	0	0	0	0	0	0	0	0	0	0	0	0
M. St. P. & S. S. M.	1	0	0	0	0	554	x	x	x	0	20	0	539
M. K. C. & Tex.	....	....	....	0	0	654	2.20	1.40	3.60	....	....	....	....
N. Y., Chi. & St. L.	....	....	....	....	....	....	....	....	....	....	....	....	....
N. Y. C. Lines East	....	....	....	....	....	....	....	....	....	....	....	....	....
N. Y., Ont. & Western	0	0	0	0	5	0	2.50	1.00	3.50	0	0	0	0
Northern Pacific	18	0	0	0	0	504	....	....	2.92	0	0	0	0
Oregon Short Line	5	0	0	0	0	182	0	0	0	0	0	0	0
Pitts. & Lake Erie	....	....	....	....	....	....	....	....	....	....	....	....	....
Southern Ry.	0	2	0	0	0	1150	0	0	0	0	2	0	....
Texas & Pacific	0	0	0	0	0	311	....	....	2.17	....	13	0	13
Transcontinental	....	....	....	....	....	....	....	....	....	....	....	....	....
Vandalia	0	0	0	0	0	0	....	....	....	....	....	....	....
Western Maryland	0	0	0	0	0	0	....	....	....	....	....	....	263
Western Pacific	0	0	0	0	0	92	x	x	x	0	0	0	118
Wheeling & Lake Erie	0	0	0	0	0	6	x	x	x	0	0	0	208
A. T. & S. F.	4	2	....	....	....	....	....	....	....	....	....	....	....
C. & N. W. Ry.	1	....	....	0	0	1250	2.00	2.00	4.00	0	410	0	1660
C. H. & D. Ry.	0	0	0	0	0	56	2.50	1.50	4.00	0	0	0	....
El Paso & S. W. Ry.	0	0	0	0	0	131	x	x	x	0	0	0	156
Lake Erie & W. Ry.	....	....	....	....	....	....	....	....	....	....	....	....	....
Lehigh Valley Ry.	0	0	0	0	0	0	....	....	....	0	0	0	....
Monon	0	0	0	0	0	104	x	x	x	0	2	0	106
Penn. (Lines West)	0	0	0	0	0	0	0	0	0	0	0	0	....
Totals Reported	37	18	0	75	5	11,206	....	....	....	....	9.98	4	8815
20 Roads as Reported 1914	147					5160	....	....	....	....	932		....
18 Roads Reported 1912	....	....	....	....	....	....	....	....	....	....	....	....	....
Grand Totals	184	18	0	75	5	16,366	....	....	....	....	1930		....

RAILROAD	LAMPS IN SHOP, STATION AND YARD LIGHTING																					
	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69		70	71	72
							VACUUM TYPE					GAS FILLED TYPE											
	Arc Lamps, A. C. Multiple	Arc Lamps, A. C. Series	Arc Lamps, D. C. Multiple	Arc Lamps, D. C. Series	Magnetite Arc Lamps	Flaming Arc Lamps	100-Watt Mazda B Lamps	150-Watt Mazda B Lamps	250-Watt Mazda B Lamps	400-Watt Mazda B Lamps	500-Watt Mazda B Lamps	100-Watt Mazda C Lamps	200-Watt Mazda C Lamps	300-Watt Mazda C Lamps	400-Watt Mazda C Lamps	500-Watt Mazda C Lamps	750-Watt Mazda C Lamps	1000-Watt Mazda C Lamps	Watt Mazda Series, C. P.	C. P. and Number of Lamps	Cooper Hewitt Lamps	Quartz Tube Lamps	Nernst Lamps
Atlantic Coast Lines	18	0	0	0	0	2	160	295	55	30	12	0	0	0	0	0	0	0	100	412	0	0	0
Baltimore & Ohio	x	208	1057	0	235	161	124	933	3	533	341	0	0	0	0	0	16	22	....	615	0	0	0
Canadian Northern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Canadian Pacific	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Chicago & Alton	0	0	15	0	0	0	210	0	184	0	367	0	0	0	0	0	0	0	0	....	13	0	0
Chicago & Western Indiana	27	96	4	....	2	137	513	220	76	41	1	9	5	27	0	1	1	1	600	49	....	....	....
C. B. & Q.	438	21	27	0	0	15	75	12	5	0	0	0	5	2	....	....	....	....	....	....	0	0	0
C. M. & St. P.	0	0	270	0	0	0	0	12	0	30	0	0	0	0	0	0	0	0	0	0	20	0	0
Buffalo, Roch. & Pitts.	16	54	127	0	0	0	18	35	15	0	0	0	0	0	0	0	0	0	20	57	0	0	0
C. C. C. & St. L.	0	0	20	0	12	0	100	500	800	....	....	45	27	....	....	....	....	....	....	....	204	....	....
Delaware & Hudson	0	36	0	0	0	270	1500	0	400	0	0	0	0	0	10	0	0	10	0	0	0	0	0
Del. Lack. & West.	404	235	6	....	59	45	3386	881	577	....	224	....	....	....	....	....	....	....	600	43	....	....	....
Denver & Rio Grande	123	4	0	0	10	0	104	34	94	2	0	2	3	6	5	0	0	0	0	0	0	0	0
Ill. Central	10	35	0	0	0	20	3060	600	520	715	30	200	200	0	150	25	100	50	....	6	48	0	0
Kan. City Southern	....	....	130	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Louisville & Nashville	78	52	12	634	....	26	963	68	132	0	0	0	0	0	7	20	33	15	600	55	0	2	0
Michigan Central	0	130	0	0	0	91	1500	0	440	0	0	0	0	5	0	0	3	0	0	....	0	0	0
M. St. P. & S. S. M.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
M. K. C. & Tex.	130	122	74	0	0	0	6	237	2	0	0	0	0	60	2	10	....	6	....	....	....	....	....
N. Y., Chi. & St. L.	0	0	4	0	0	3	0	3	33	0	7	0	0	2	0	0	6	0	0	0	0	0	0
N. Y. C. Lines East	40	0	0	0	0	10	237	295	151	74	414	0	0	0	0	0	0	0	400	38	72	0	0
N. Y., Ont. & Western	0	0	12	331	10	0	312	0	0	0	0	80	0	100	0	0	42	6	0	0	2	0	0
Northern Pacific	124	0	58	0	0	14	304	276	109	103	0	0	26	17	12	12	0	0	250	74	2	0	0
Oregon Short Line	2	10	0	0	0	45	410	72	696	140	8	0	0	16	4	0	0	0	0	0	0	0	0
Pitts. & Lake Erie	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Southern Ry.	200	200	200	200	0	0	0	50	30	0	0	12	0	0	0	0	0	0	0	0	2	0	0
Texas & Pacific	0	0	0	0	0	0	48	0	51	0	2	0	0	0	0	0	0	0	....	....	0	0	0
Transcontinental	8	58	0	0	0	253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	769	0	0
Vandalia	7	29	0	0	0	0	20	0	66	0	0	0	2	0	0	0	0	0	250	1	0	0	0
Western Maryland	82	0	5	0	0	26	22	165	61	20	3	0	0	0	144	0	0	0	0	0	0	0	0
Western Pacific	0	0	0	0	0	0	125	125	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wheeling & Lake Erie	150	0	15	0	0	0	150	0	100	0	35	0	0	0	0	0	0	0	0	0	0	0	0
A. T. & S. F.	633	117	....	....	....	....	550	850	300	150	250	....	....	....	....	....	....	2	....	....	....	....	....
C. & N. W. Ry.	....	....	....	....	....	....	1145	630	1425	....	....	....	12	30	6	12	10	....	....	....	55	....	....
C. H. & D. Ry.	0	0	21	0	0	0	70	0	68	0	5	0	40	0	0	0	0	0	0	0	0	0	0
El Paso & S. W. Ry.	0	0	0	10	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	32	0	0
Lake Erie & W. Ry.	....	....	....	....	....	....	6	11	74	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lehigh Valley Ry.	322	105	6	82	....	20	......	214	20	....	....	....	....	....	....	....	....	....	250	1	....	....	....
Monon	....	....	....	....	....	1	150	60	75	....	....	....	....	....	....	6	....	....	....	....	....	....	....
Penn. (Lines West)	44	20	38	129	178	14	309	290	727	48	276	7	0	0	0	0	4	0	0	0	171	4	0
Totals Reported	2673	1533	1901	1386	406	1106	15,677	6875	6908	1906	1985	356	370	259	340	86	211	112	....	1361	1390	6	....
20 Roads as Reported 1914	2500	3381	2840	2840	975	620	......	3851	5130	589	333	90	90	90	....	....	....	....	....	....	737	36	570
18 Roads Reported 1912	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Grand Totals	5173	4914	4741	4226	1381	1726	15,677	10,729	12,038	2495	2318	446	460	349	340	86	211	112	....	1361	2127	42	570

RAILROAD	PURCHASED OR GEN. Power in Shops				GENERATORS				Sub. Sta. Equip.	
	73	74	75	76	77	75	79	80	81	82
	Purchased		Generated							
	No. of Shops	H. P. Total Connected Load	No. of Shops	H. P. Total Connected Load	Total K. V. A. Capacity, A. C.	Number of Generators A. C.	Total K. W. Capacity D. C.	Number of Generators, D. C.	Total Capacity D. C. End	Number of Sets.
Atlantic Coast Lines	3	109	3	2902	1680	5	530	7	250	3
Baltimore & Ohio	9	5926	13	4738	3535	38	780	7	1025	8
Canadian Northern	....	....	....	....	....	....	....	....	....	....
Canadian Pacific	6	7500	13	2575	4840	89	1300	17	1250	3
Chicago & Alton	....	2461	....	2749	60	1	1005	10	200	2
Chicago & Western Indiana	....	....	....	....	1400	5	242	2	190	5
C. B. & Q.	3	290	10	6070	2060	7	2080	22	....	....
C. M. & St. P.	9	1790	21	9720	350	2	4732	43	....	....
Buffalo, Roch. & Pitts.	3	130	4	1402	1179	5	493	6	530	6
C. C. C. & St. L.	6	805	13	6152	1975	7	1945	9	....	....
Delaware & Hudson	5	4500	1	600	626	3	350	1	350	1
Del. Lack. & West.	2	1061	4	7709	4700	9	115	4	760	9
Denver & Rio Grande	5	2120	0	0	0	0	37	2	0	0
Ill. Central	21	5066	4	3490	2360	8	530	4	75	8
Kan. City Southern	....	....	....	....	....	....	757	9	....	....
Louisville & Nashville	5	695	7	5474	300	....	3465	....	0	0
Michigan Central	9	3020	1	3036	825	4	....	....	2000	2
M. St. P. & S. S. M.	....	....	....	....	....	....	900	6	....	....
M. K. C. & Tex.	....	1796	....	1758	525	3	1065	6	200	2
N. Y., Chi. & St. L.	1	15	4	150	....	....	75	1	....	....
N. Y. C. Lines East	3	955	2	3925	2200	4	1565	12	200	1
N. Y., Ont. & Western	0	0	6	1557	0	0	1665	15	0	0
Northern Pacific	12	1516	4	4247	1000	2	1300	18	0	0
Oregon Short Line	5	2870	1	22	100	1	650	4	300	1
Pitts. & Lake Erie	2	300	4	2400	650	3	900	7	0	0
Southern Ry.	6	300	12	2005	1090	5	915	12	220	5
Texas & Pacific	3	130	3	1191	0	0	523	....	0	0
Transcontinental	0	0	13	4781	3350	20	530	9	525	4
Vandalia	4	154	1	144	200	2	0	0	176	4
Western Maryland	2	145	2	1478	950	4	250	1	105	2
Western Pacific	4	1477	....	....	....	....	....	....	....	....
Wheeling & Lake Erie	1	50	5	3195	250	1	900	7	75	1
A. T. & S. F.	6	1705	21	5511	4410	38	1185	11	....	....
C. & N. W. Ry.	7	1005	13	8241	3000	11	3950	23	500	2
C. H. & D. Ry.	2	30	3	521	0	0	381	7	500	1
El Paso & S. W. Ry.	0	0	1	473	....	....	300	3	0	0
Lake Erie & W. Ry.	8	220	....	....	....	....	....	....	....	....
Lehigh Valley Ry.	7	337	2	3162	2650	4	950	6	....	....
Monon	....	....	....	....	0	0	150	2	120	1
Penn. (Lines West)	4	1498	16	9708	2765	14	2709	30	0	0
Totals Reported	163	49,976	202	111,370	47,720	295	44,924	363	9601	75
20 Roads as Reported 1914	80	27,453	135	80,498	91,821	138	36,348	309	....	....
18 Roads Reported 1912	....	....	....	....	....	....	....	....	....	....
Grand Totals	243	77,429	337	191,868	139,541	433	81,272	772	9601	75

DIRECT CURRENT

	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	35	40	50	75	100	125	150	200	225	300	350
Atlantic Coast Lines	1	2	1	3	4	12	15	22	18	16	18	7	4	1	1	2	1		1						
B. & O.	15	7	0	10	6	9	14	27	8	31	23	50	13	16	15	1	18	7	7	4	0	2			3
Can. Pac. Estn. Lines		4	2	1	0	1	5	10	2	12	18	5	1	6	6										
Chi. & Alton	4	1			1	1	13	32	14	25	30	8	22		1	4	7	1							
Chi. & West. Ind.		1	1			2	7	8	2	2	5	1				1									
C. B. & Q.	5			2	1	11	16	50	23	36	35	12	15	1	6	6	11	1							
Chi. M. & St. P.		9	1		12	13	9	27	17	62	62	46	4	128	4	11	32	6		1					
Buf. Roch. & Pitts.						2	4	7	13	24	8	8	2	3		2	3	1							
C. C. C. & St. L.				1	2	7	10	12	5	7	5	6		4		4	4								
D. & H.		2		5	1	13	3	4	7	24	6	8	7	2	2		2	2							
D. L. & W.	1		1	10		18	20	47	30	28	4	8	5	14	1		2	1	2						
El Paso S. W.	2					2	1	3	1	2	6		1		10										
Ill. Cent.		1				2	2	1	3		2		2				6	1	8						
L. & N.			6	11	3	2	9	22	32	30	70	20	6	29	7	2	26	7	3	2					
Mich. Cent.	1	1		3		5	1	2	1	2	1		5												
M. St. P. & S. S. M.				1	1	1	16	19	25	13	24	20	11		4	9	4								
L. V. R. R.		1		2			6	6	11	15	7	6	8	2	1	3	1	3							
M. K. C. & T.	1			2	1	5	5	19	21	22	17	17	3	28	11	2	4	1	1						
N. Y. C. & St. L.				1	1	3	1				1	1		1									9		
N. Y. C. Lines East			1	4	1	10	19	29	38	35	20	14	13	1	4	3	6				1				
N. Y. Ont. & Wn.						7	9	18	8	27	1	20	8	7	1	1		4							
Nor. Pac.	5	2	2	4	5	19	36	33	36	21	37	18	7		1		10	1	2		1				
O. S. L.		1	1	1		5	9	16	20	22	11	7	5	1		3									
Pennsylvania	93	15	6	67	23	75	140	246	156	239	136	174	68	54	20	47	50	18	6	1				1	
Southern							25	16	13	18	18	27	6		7		9	6	4						
Tex. & Pac.	2	3		3		2	4	5	2	3			3		1			5	1	1	1				
Trans-Continental		1				9	5	12	4	8	4		2	3		3	2	1							
Union Pac.	5	2	2	4	5	19	36	33	36	21	37	18	7		1		10	1	2		1				
Wn. Maryland				2		5	6	10	24	11	7	4	1	2			1								
Wheeling & L. E.	4			1		3	5	7	7	19	17	17	5	3	6	5	6	1			1				
A. T. & S. F. Ry.				3		5	15	25	21	26	19	16	10	3	1	1	2	1							
C. & N. W.	17	5	3	10	7	24	38	67	30	33	26	13	24	1	15	1	7	7	2						
C. H. & D.		1				1	1		6	6			5	1	1	1	2	2	3	4		4			
El Paso & S. W.	2					2	1	3	1	2	6		1		10										
Lehigh Valley		1		2			6	6	11	15	7	6	8	2	1	3	1	3							
Monon						1	3	5			1			1			1								
Penn. (Lines West)	1		1	8	4	17	21	30	41	66	29	35	23	14	12	8	11	15							
TOTALS	159	60	28	161	77	314	536	881	687	935	718	592	305	320	150	123	239	86	42	13	5	6	9	1	3

SINGLE PHASE

	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	40
Atlantic Coast Lines	1														
Can. Pac. East. Lines	3	1	1	9	1	4									
Chi. & West. Ind.							1								
C. B. & Q.	1							3							
D. & H.	6	1													
D. L. & W.											1				
D. & R. G.	1	1		2		1							2		
Ill. Cent.	6	2		8		1	2			1					
Pennsylvania	63	2		3		8	1	7	2	6	3	2		3	2
Trans-Continental				1											
Vandalia	1	3		1	1										
West. Maryland	1	1		1											
Wheeling & L. E.	12							1							
TOTALS	95	11	1	25	2	14	4	11	2	7	4	2	2	3	2

TWO PHASE

	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	35	40	50	75	125	200
C. B. & Q.						1														
B. R. & P.						2		8	4	4	3	6		2					1	
C. C. C. & St. L.												2								
Ill. Cent.											1									
L. V.			1	1			3	11	19	13	17	17	11	8	7	4	4			
Pennsylvania	1	4	1	10		6	10	62	38	84	70	40	3	22	4	17	10	1		
Pex. & Pac.											1				1					
Lehigh Valley			1	1			3	11	19	13	17	17	11	8	7	4	4			2
Monon							1	3	1		2	1								
TOTALS	1	4	3	12		9	16	95	81	114	111	83	25	40	19	25	18	1	1	2

THREE PHASE

	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	35	40	50	75	100	125	150	200	225	250	300	350	400
B. & O.	3	1	0	0	0	3	7	6	4	17	34	78	1	18	6	17	10	21	1								
Can. Pac. Ea. Lines						7	26	70	15	80	58	65	2	68	5	9	14	20	8								
Chi. & Alton	1						10	10	8	9	15	11	2	4		3		3	1								
Chi. & West. Ind.				2	1	18	14	30	7	9	23	16	1	5		1	2										
C. B. & Q.			5	1		1	11	28	17	33	26	13	2	20	2	6	5	1									
C. M. & St. P.											4	4															
B. R. & P.										2	1			1													
C. C. C. & St. L.						5	16	20	40	18	21	10	14		9	1	5	4		2							
D. & H.						12	3	12	5	8	27	17	9	3	8	1	14	2	1								
D. L. & W.	2	3	1	11	5	32	112	70		74	56	46	5	21	2	12	15			2	1						
D. & R. G.				2			4	4	1	14	13	4	5	5	1	2	11	5	1		1						
Ill. Cent.	1	3	2	18	2	28	46	58	52	68	90	41	8	22	3	9	18	5	6								
L. & N.								1	21	1	12	2	2		4		2		1								
Mich. Cent.		2		15		9	11	34	38	16	27	27	16	23	10	2	34	13	1		1		2				
L. E. & Wn.								1	1	1	5	1				1		1									
N. Y. C. Lines East	1			7	2	3	11	51	23	34	18	17	8	10	6	3	1	1				1					
Nor. Pac.	3	3		1		7	12	35	30	13	24	14	7	14	1	3	9	2			2				1		
O. S. L.	2	2		5		5	8	12	6	23	9	11	3	2	1	3	4	2									
Pennsylvania	1	1	2	5	1	23	26	53	39	59	52	48	7	26	23	19	12	4	2	1		5		3			
Southern							7	12	17		24	21	1		10		15	2	1								
Trans-Continental	6	6		5		19	43	37	24	1	29	20	13	12	10	12	3	1		5						1	2
Union Pac.	3	3		1		7	12	35	30	13	24	14	7	14	1	3	9	2			2				1		
Vandalia			1			1		1	1		7	1	2				1										
Wn. Maryland			1			2	2	13	3	10	5	5	2	1	2	2	3	3									
Wn. Pacific		4		1	1	5	13	26	17	41	3	3	4		1		4		1	2	2	1					
Wheeling & L. E.											1			1		1	1										
A. T. & S. F.						2	2	30	18	29	34	45	16	33	14	6	7	2	1								
C. & N. W.		4		8		10	28	33	9	26	11	17	9	10	2	17	8	4									
C. H. & D.								1			2			1													
Lake Erie & W.								1	1	1	5	1				1	1										
Penn. (Lines West)	1	6		6	1	2	8	36	17	32	39	21	14	15	9	5	15	7	4		4		1				
TOTALS	24	39	12	88	13	201	433	695	444	634	709	573	160	329	130	139	223	106	29	12	13	7	2	3	2	1	2

TABLE I.

INCREASE IN CAR LIGHTING EQUIPMENT IN U. S. AND CANADA.

	Total Number 1911	Total Number 1912	Total Number 1914	Total Number 1915
Electric lighted cars	11,017	13,115	18,936	18,793
Cells, lead battery	202,744	222,989	259,842	307,147
Cells, nickel iron	....	4,855	31,883	36,653
Straight storage cars	1,372	2,078	2,707	24,042
Headend generator sets	192	291	273	273
Axle generator cars—60 and 30 volt	5,900	7,198	12,458	13,079
Water for batteries—				
Distilled water			116	248
Tap water			57	54
Pipe condensation			15	17
Filtered water			10	1
Industrial trucks—				
Baggage handling			187	178
Freight house			124	132
Battery and commissary			14	14
Electric tractors			1	1
Shop trucks			45	48
Motor cars operated on rails for passenger traffic—				
Straight gasoline cars			197	184
Gas electric cars			30	18
Electric headlights—				
Arc			12,432	16,446
Incandescent			932	1,287
Lamps—				
Arc lamps, a. c.			9,600	4,206
Arc lamps, d. c.			8,096	3,287
Magnetype arc lamps			1,429	1,381
Flaming arc lamps			1,252	1,726
150 watt Mazda			9,030	10,729
250 watt Mazda			11,205	12,038
400 watt Mazda			1,576	2,495
500 watt Mazda			734	2,318
Gas filled Mazdas, Type C (all sizes)			489	3,365
Cooper Hewitt's			1,516	2,127
Quartz tube			55	42
Generators, a. c. (total number)			264	433
Total h. p. a. c. generators			123,401	139,541
Generators, d. c. (total number)			566	772
Total h. p. d. c. generators			65,077	81,272

figures were known the totals given in all the tables of this report would be materially increased, in many cases nearly 25 per cent. However, an interesting study can be made of the information at hand.

Car Lighting Data.

Upon referring to Table 3, comparing the statistics with those of past years, as is done in Table 1, it will be noted that although there was a large increase in car lighting equipment from 1911 to 1914, there has been little or no change in the electric car lighting situation during the past year, except in a few minor details.

Lamps.

It will be noted from Table 1 that there has been a great increase in the number of gas filled Mazdas and also the larger sizes of vacuum type Mazdas, but here the percentage increase is not so marked. The number of Cooper-Hewitt lamps reported this year is also considerably greater than last year.

Purchase of Power.

It is a remarkable coincidence that, although the total number of shops reported this year is practically twice that of last year, that the percentage of the shops at which power is purchased remains identical, being 42 per cent in each case.

As to the total horsepower of the connected load at these shops, however, last year the total was 208,671 horsepower, and the purchased power represented 30 per cent of this total, whereas this year the total horsepower connected load represented 269,297 horsepower, of which power was purchased for 29 per cent of the total, the percentage relation again remaining almost identical with last years figures.

Respectfully submitted,

Edward Wray, Chairman, Railway Electrical Engineer.
C. J. Causland, Penna. R. R.
G. W. Cravens, C. & C. Elec. & Mfg. Co.
W. A. Del Mar, Interborough Rapid Transit Co.
A. J. Farrelly, C. & N. W. Ry.
J. E. Gardner, C., B. & Q. Ry.
W. M. Wiggins, Pullman Co.

Committee on Wire Specifications

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Part I--General

The Committee on Wire and Cable Specifications has devoted itself to improving the 1914 specifications, to make them conform with the latest engineering practice, especially the 1915 Standardization Rules of the American Institute of Electrical Engineers.

The committee recognizes that various grades of rubber insulation may be used with advantage under different conditions, according to the degree of permanence desired, but where great reliability is required, a grade of insulation at least equal to that called for in the following specifications should be used. The committee does not undertake to express an opinion on the relative merits of compounds with a mineral base, and those containing organic substances.

The chemical clauses of the rubber specifications are those recommended by the Joint Rubber Insulation Committee.

The design of cables for potentials in excess of 15,000 volts is in a state of development where standardization would embarrass the manufacturers and retard progress. The committee has, therefore, decided to make the specifications cover potentials to 15,000 volts only, as in 1914.

The Wire and Cable Committees of the American Electric Railway Association and American Society for Testing Materials continue to work in collaboration with this committee, with the result that the three associations now have substantially similar specifications.

In order to facilitate the use of the specifications the committee deems it advisable to reprint the entire 1914 specification with the modifications proposed.

Part II--Form of Specifications

The specification (Part III) covers labor and material for all kinds of wire and cables for railway, power and lighting purposes, but does not specify the size or make-up of any particular kind of wire or cable.

It must, therefore, be supplemented by certain specific data whenever used. This may be accomplished in either of three ways.

First: The man who is ordering wire or cable may be provided with a series of printed, blue printed or mimeographed specifications, which are mere descriptions of cable make-up and refer to the general specifications for details of materials and tests. When ordering wire the proper specification is selected and sent to the purchasing agent with a requisition stating the size, quantity, maximum and minimum length, time and place of delivery, and approximate price.

Second: The man who is ordering wire or cable writes out a complete specification, using in it such clauses as he requires from the General Wire and Cable Specification.

Third: The man who is ordering wire or cable may be provided with a series of printed or mimeographed order forms, which he fills out and forwards to the purchasing agent, who copies them on the regular form with which he calls for bids and sends the latter to the manufacturers.

The first plan generally works better in practice and has been adopted by several important companies. The New York Central R. R. Co. uses mimeographed subsidiary specifications and the Pennsylvania R. R. Co. uses blue prints, from letter size tracings, which often show sketches of the cable make-up in addition to the tabulated data.

Which of the three plans should be adopted depends upon local conditions, and must be decided for each individual case.

It is usual for railroad companies to copy such parts of Part III of this report as applies to their needs and refer to it as the General Wire and Cable Specifications of the ——— R. R. Co.

The following tables give lists of items which should be covered by subsidiary specifications or order forms. The following three items should appear on the requisition which goes to the purchasing agent:

(a) Where to be delivered.
(b) When to be delivered.
(c) Approximate cost.

I. Bare or Weatherproof Aerial Wire or Cable.

Items.

(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet..............
(d) Size of conductor.................................
  A. w. g. or....................................
  Circular mils...................................
(e) Material of conductor,
  hard drawn copper.............................
  aluminum ....
  copper-clad steel..............................
  phono-electric metal..........................
(f) Solid or stranded.................................
(g) Stranding, standard or special.................
(h) Number of strands (if special).................
(i) Condition of central wire (if conductor is stranded), hard drawn.....................
  semi-hard drawn...............................
(j) Number of impregnated (weatherproof) cotton braids, each $\frac{1}{32}$ in. thick......................
(k) Whether to be delivered in coils or on reels.....

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

II. Bare Conductors Not for Aerial Spans.

Items.

(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet..............
(d) Size of conductor (if not extra flexible).........
  A. w. g. or....................................
  Circular mils...................................
(e) Size of conductor (if not extra flexible).........
(f) Material of conductor,
  soft-annealed copper..........................
  aluminum ....
(g) Tinned or not tinned............................
(h) Solid or stranded.................................

(i) Stranding, standard or special..................
(j) Stranding (if special), concentric or rope lay....
(k) Number of strands (if special)..................
(l) Number of wires in strand (if rope lay)........
(m) Whether to be delivered in coils or on reels......

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

III. Single Conductor Insulated Wire or Cable for Indoor Service.

Items.
(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet...............
(d) Size of conductor (if not extra flexible).........
A. w. g. or..
Circular mils.....................................
(e) Size of each wire (if extra flexible), A. w. g.....
(f) Material of conductor,
soft-annealed copper, or.......................
hard-drawn copper...............................
(g) Tinned or not tinned.............................
(h) Solid or stranded.................................
(i) Stranding, standard or special..................
(j) Stranding (if special), concentric or rope lay....
(k) Number of strands (if special)..................
(l) Number of wires in strand (if rope lay)........
(m) Voltage of circuit................................
(n) Separator (if any), to be yarn or tape..........
(o) Insulation, material,
Grade A rubber or.............................
Code rubber, or................................
Varnished cambric, or.........................
Impregnated paper...............................
(r) Thickness of insulation (if special), inches......
(p) Tapes, rubber filled cotton, number of..........
(q) Number of braids of the following kinds, in the order given, proceeding outward,
Impregnated cotton braids...................
(s) Glazed cotton braids...........................
(t) Lead sheath or no lead sheath..................
Whether to be delivered in coils or on reels......

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

IV. Single Conductor Insulated Wire or Cable for Exposed Service.

Items.
(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet..............
(d) Size of conductor (if not extra flexible), A. w. g. or..................................
Circular mils.....................................
(e) Size of each wire (if extra flexible), A. w. g.....
(f) Material of conductor,
soft-annealed copper, or.......................
hard-drawn copper...............................
(g) Solid or stranded.................................
(h) Stranding, standard or special..................
(i) Stranding (if special), concentric or rope lay....
(j) Number of strands (if special)..................
(k) Number of wires in strand (if rope lay)........
(l) Voltage of circuit................................
(m) Insulation, material,
Grade A rubber or.............................
Code rubber, or................................
Varnished cambric...........................
(n) Thickness of insulation (if special), inches......
(o) Tapes, rubber filled cotton, number of..........
(p) Number of braids of the following kinds, in the order given, proceeding outward,
Impregnated cotton ....
Impregnated hemp ....
(q) Lead sheath or no lead sheath..................
(r) Steel tape armor or no armor..................
(s) Jute over armor (if not wanted say "no").......
(t) Whether to be delivered in coils or on reels......

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

V. Single Conductor Insulated Wire or Cable for Underground Conduit Service.

Items.
(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet..............
(d) Size of conductor (if not extra flexible),
A. w. g. or.....................................
Circular mils.....................................
(e) Size of each wire (if extra flexible), A. w. g.....
(f) Voltage of circuit................................
(g) Insulation, material,
Grade A rubber compound...................
Impregnated paper, or.......................
Varnish cambric..............................
(h) Thickness of insulation (if special), inches......
(i) Pressure wire (if any), size ....
(j) Pressure wire (if any), location, stranded with conductor, or between insulation and braid or sheath...................................
(k) Pressure wire (if any), insulation material......
(l) Whether to be delivered in coils or on reels....

The conductor shall be of soft annealed copper with standard stranding. The insulated conductor shall be enclosed in a lead sheath.

All workmanship and materials shall conform in every respect with the requirement of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

VI. Single Conductor Submarine and Other Armored Cables.

Items.
(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet...............
(d) Size of conductor,
A. w. g. or...
Circular mils.....................................
(e) Number of strands, each conductor (if special)..
(f) Voltage of circuit.................................
(g) Insulation, material,
Grade A rubber, or..............................
Varnished cambric...............................
(h) Thickness of insulation (if special), inches......
(i) Tapes, rubber filled cotton, number of..........
(j) Impregnated cotton braids, number..............
(k) Lead sheath or no lead sheath..................
(l) Thickness of sheath (if special), inches........
(m) Armor, steel wire or steel tape..................
(n) Jute over armor (if not wanted, say "no")......
(o) Whether to be delivered in coils or on reels......

The conductor shall be of soft-annealed copper. All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

VII. Single Conductor Wires and Cables for Train Lighting.

Items.
(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet...............
(d) Size of conductor, A. w. g.......................
(e) Number of strands...............................
(f) Voltage of circuit...............................
(g) Separator (if any), to be yarn or tape..........
(h) Thickness of insulation, inches..................
(i) Tapes, rubber filled cotton, number of..........
(j) Number of impregnated cotton braids..........
(k) Whether to be delivered in coils or on reels......

The conductor shall be of tinned soft-annealed copper, and shall be insulated with grade A rubber.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

VIII. Multiple Conductor Cable.

Items.
(a) Quantity required, feet..........................
(b) Maximum length, each piece, feet...............
(c) Minimum length, each piece, feet...............
(d) Number of conductors...........................
(e) Size of each conductor (if not extra flexible)....
A. w. g. or...
Circular mils.....................................
(f) Size of each wire (if extra flexible), A. w. g.....
(g) Stranding, standard or special..................
(h) Stranding (if special), concentric or rope lay....
(i) Number of strands in conductor (if special)....
(j) Number of wires in strand (if rope lay)........
(k) Voltage between conductors....................
(l) Voltage from conductors to ground..............
(m) Separator (if any), to be yarn or tape..........
(n) Insulation over each conductor, material,
Grade A rubber, or...........................
Code rubber, or...............................
Varnished cambric, or.........................
Impregnated paper.............................
(o) Thickness of insulation over each conductor (if special), inches.........................
(p) Covering over each insulated conductor,
Rubber-filled cotton tape, or..................
Impregnated cotton braid, or..................
Glazed cotton braid...........................
(q) Tracer in each layer of conductors (state whether required) ....
(r) If braids are to be differently colored as tracers, state sequence of colors.....................
(s) Jute laterals (state whether required)..........
(t) Pressure wire (if any), size A. w. g............
(u) Tape over each layer of conductors (if required), material,
Rubber-filled cotton, or.......................
Dry-cotton, or..................................
Impregnated paper, or.........................
Dry-paper, or...................................
Varnished cambric.............................
(v) Insulation over all conductors, i. e., belt (if any) material,
Grade A rubber, or............................
Varnished cambric, or.........................
Impregnated paper.............................
(w) Thickness of insulation belt (if special), inches..
(x) Tape over finished group of conductors (or over belt if any) material,
Impregnated cotton, or........................
Varnished cambric.............................
(y) Jute filler under braid or sheath (state whether required) ....
(z) Jute filler (if other than 8-ply), state size required ....
(aa) Number of braids of each of the following kinds in the order given, proceeding outward,
Impregnated cotton braids.....................
Glazed cotton braids...........................
Impregnated hemp braids......................

(ab) Lead sheath or no lead sheath..................
(ac) Thickness of sheath (if special), inches..........
(ad) Armor (if any), steel wire or steel tape..........
(ae) Jute over armor (if not wanted, say "no")......
(af) Maximum overall diameter (if limit is necessary), inches..............................
(ag) Whether to be delivered in coils or on reels......

The conductors shall be of soft-annealed copper, tinned if rubber insulated, otherwise not tinned. The insulation of the pressure wire, if any, shall be of the same material as on the main conductors. Two conductor cables shall be flat, unless otherwise specified. If there are more than two conductors, they shall be assembled helically.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

Part III--General Specifications

(These specifications are to be sent to the manufacturers yearly and are merely referred to when ordering wire or cable.)

General Clauses.

1. (a) **Workmanship and Materials:** All workmanship and materials shall be the best of their respective kinds and shall be in full accord with the best engineering practice.

(b) **Inspection:** The wire or cable shall be accessible for inspection by an authorized representative of the purchaser, who shall be afforded all necessary facilities to assure him that the materials used, and the process of manufacture, conform with the specifications. In the case of conductors insulated with rubber compound with any kind of covering and conductors insulated with varnished cloth covered with dry or flameproof braid, the braid or sheath shall not be applied until the inspector has approved (in writing) the insulation. All other wires and cables will be inspected in their completed form.

(c) **Notification:** The contractor shall notify the designated representative of the purchaser sufficiently in advance of the completion of the wire or cable to enable inspection to be arranged for.

(d) **Factory Tests:** The manufacturer shall furnish suitable apparatus and shall make the tests in the presence of the railroad company's representative, who shall be allowed every reasonable facility to assure himself that the requirements of this specification have been complied with, except that when chemical analysis of rubber insulation is required it shall be made by the purchaser.

(e) **A. I. E. E. Standardization Rules:** Unless otherwise specified, the standards for wires and cables in the Standardization Rules of the American Institute of Electrical Engineers, shall be complied with. (See Part IV of this report.)

(f) **Thickness of Insulation:** Unless otherwise specified the thickness of insulation for potentials up to 7000 volts, shall be the minimum allowed by the National Fire Protection Association, as summarized in Table I. For higher voltages, the thickness of insulation will depend upon the conditions of service.

TABLE I.

Thickness of Insulation (64ths. inch). Recommended by the National Fire Protection Association.

Cir. Mills	Working Voltage					
	0-600	1,500	2,500	3,500	5,000	7,000
2,000,000	8	9	10	11	14	18
1,750,000	8	9	10	11	14	18
1 500,000	8	9	10	11	14	18
1,250 000	8	9	10	11	14	18
1,000 000	7	8	9	10	12	16
900,000	7		9	10	12	16
800,000	7	8	9	10	12	16
700,000	7	8	9	10	12	16
600,000	7	8	9	10	12	16
500 000	6	7	8	9	12	16
400,000	6	7	8	9	12	16
300,000	6	7	8	9	12	16
225,000	6	7	8	9	12	16
A. W. G. or B. & S.						
0000	5	6	7	8	12	16
000	5	6	7	8	12	16
00	5	6	7	8	12	16
0	5	6	7	8	12	16
1	5	6	7	8	12	16
2	4	5	6	8	12	16
4	4	5	6	8	12	16
6	4	5	6	8	12	16
8	3	4	6	8	12	16
10	3	4	6	8	12	16
12	3	4	6	8	12	16
14	3	4	6	8	12	16

(g) **Stranding:** Unless otherwise specified, the stranding shall be concentric and in accordance with Table II. (See A. I. E. E. Standardization Rules for stranding of bare cables.)

(h) **Repairs and Joints of Insulation:** If exigencies of manufacture require repairs or joints in the insulation, the work shall be done in such a way as to leave the repaired part or joint, and all parts affected by it, as strong and durable electrically as the remainder of the insulation. In the case of rubber insulation, patches and joints should be properly vulcanized.

(i) Tags containing the following information shall be securely attached to all coils, spools or reels of wire:

Marking of Packages.

Coil Under Wrapping	Coil Over Wrapping	Spool Under Wrapping	Spool Over Wrapping	Reel
....	....	....	Gross lb.	Gross lb.
Net lb.	Net lb.	....	Net lb.	Identification number
....	Length, ft.	....	....	Length, ft.

The following items to be on tags both under and over wrappings of coils and spools, and on the side of reels.

Size of conductor.
Number of conductors, if more than one.
Kind of insulation.
Thickness of insulation.
R. R. Co's. requisition number.
R. R. Co's. order number.

TABLE II

Range of Sizes	Minimum Number of Wires in Conductor
2,000,000—1,600,000 Circ. Mills	127
1,500,000—1,100,000	91
1,000,000— 550,000	61
500,000— 250,000	37
No. 0000—No. 1 A. W. G. or B. & S.	19
2— 8	7
Smaller Sizes	1

Electrical Tests.

2. (a) **High Potential Tests:** The high potential test voltage shall be applied for five (5) minutes, shall have a frequency not exceeding one hundred (100) cycles per second, and shall approximate as closely as possible to a sine wave. The source of energy shall be of ample capacity.

TABLE III.

Stranding of Flexible Cables.

(The table which appeared in previous issues of this specification will be omitted pending final action of the Standards Committee of the American Institute of Electrical Engineers. See Table XIII of the A. I. E. E. Standardization Rules in Part IV of this report.

(b) **Insulation Resistance:** The (apparent) insulation resistance shall be measured after the high potential test, and after a one-minute electrification with a battery having an e. m. f. of not less than 100 and not more than 500 volts, and the results corrected to the standard temperature of 15.5 deg. cent. (60 deg. Fahr.). Should a cable tested in air fail to meet the above requirements the manufacturer may immerse it in water to obtain a constant temperature.

Copper, Soft, Semi-Hard and Hard Drawn.

3. The current issue of the specifications of the American Society for Testing Materials shall be complied with in every respect. Unless otherwise specified, conductors shall be of soft-annealed copper.

The conductivity of tinned copper wire shall be not less than specified in Table IV.

TABLE IV

Conductivity of Tinned Copper Wire

9 and larger	98.0	20	95.8
10	97.8	21	95.6
11	97.6	22	95.4
12	97.4	23	95.2
13	97.2	24	95.0
14	97.0	25	94.8
15	96.8	26	94.6
16	96.6	27	94.4
17	96.4	28	94.2
18	96.2	29	94.0
19	96.0	30	93.8

Tinning.

4. Tinned wire shall be provided with a heavy uniform coating of commercially pure tin without projections. Where tinned wire is supplied but not called for, the following test is not required.

Samples of wire, before stranding or covering, shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 and temperature 15.5 deg. cent. (60 deg. Fahr.) for one minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for 30 seconds and again washed.

This operation shall be repeated three times, and upon completion of the fourth cycle the sample shall show no sign of blackening.

The sodium sulphide solution shall contain an excess of sulphur and shall have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five seconds.

Separator.

5. The separator may consist of soft cotton yarn (which may be braided), or of paper or muslin tape. With the untinned conductors the separator shall completely cover the the conductors; with tinned conductors, it is desirable that the separator shall allow the insulation sufficient contact with the conductors to prevent the conductors sliding in the insulation.

Grade A Rubber Compound.

6 (a) **Composition:** The compound shall consist of Fine Para or Smoked First Latex Hevea rubber and a mineral base. It shall contain only the following ingredients:

Rubber.
Sulphur.
Inorganic mineral matter.
Refined solid paraffin or ceresin.

It shall not contain either red lead or carbon.

(b) **Result of Analysis:** After vulcanization, the compound shall conform to the following requirements, the results to be expressed as percentages of the whole sample:

Rubber, between	30 and 33% by wt.
Waxy Hydrocarbons under	4
Free Sulphur, under	0.7

After vulcanization the compound shall conform to the following requirements, results to be taken between the limits given, in proportion to the percentage by weight of rubber found:

Limits allowed for 30% Rubber Compound.

	Maximum	Minimum
Saponifiable extract	1.35	0.55%
Unsaponifiable resins	0.45	-------
Chloroform extract	0.90	-------
Alcoholic potash extract	0.55	-------
Total sulphur (see note)	2.10	-------
Specific gravity	2.10	1.75%

Limits allowed for 33% Rubber Compound.

	Maximum	Minimum
Saponifiable extract	1.50	0.60%
Unsaponifiable resins	0.50	-------
Chloroform extract	1.00	-------
Alcoholic potash extract	1.00	-------
Total sulphur (see note)	2.30	-------
Specific gravity	-------	1.67%

The acetone extract solution shall not fluoresce.

The acetone extract (60 cc.) shall be not darker than a light straw color.

Hydrocarbons shall be solid, waxy, and not darker than a light brown.

Chloroform extract (60 cc.) shall be not darker than a straw color.

Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to this specification.

Failure to meet any requirement of this specification will be considered sufficient cause for rejection.

TABLE V.

TEST POTENTIALS, KILOVOLTS

Five-Minute Tests

Rubber—Use 100 per cent of following potentials.
Varnish Cloth—Use 75 per cent of following potentials.
Impregnated Paper—Use 75 per cent of following potentials.

Size of Conductors	Thickness of Insulation, 64ths Inch							
	2	3	4	5	6	7	8	10
2,000,000 C. M.	....	....	....	....	....	....	5.0	10.5
1,750,000	....	....	....	....	....	....	6.5	11.5
1,500,000	....	....	....	....	....	....	7.0	12.0
1,250,000	....	....	....	....	....	....	7.5	12.5
1,000,000	....	....	....	....	....	5.5	8.0	13.0
750,000	...	....	....	....	....	6.5	9.0	14.0
500,000	....	...	....	2.5	5.0	7.5	10.0	14.5
250,000	....	....	....	4.0	6.5	9.0	11.0	15.5
0000 A. W. G. or B. & S.	....	....	....	4.5	7.0	9.0	11.5	15.5
000	....	....	....	5.0	7.5	9.5	11.5	15.5
00	....	....	....	5 0	7.5	9.5	11.5	15.5
0	....	....	....	5.5	8.0	10.0	12.0	15.5
1	....	....	4.0	6.0	8.0	10.0	12.0	15.5
2	....	....	4.0	6.0	8.0	10.0	12.0	15.0
4	....	....	4.5	6.5	8.5	10.0	11.5	14.5
6	....	....	5.0	6.5	8.5	10.0	11.5	14.0
8	....	3.0	5.0	7.0	8.0	9.5	11.0	13.0
10	....	3.0	5.0	6.5	8.0	8.5	10.0	12.0
12	....	2.5	5.0	6.0	7.5	8.5	9.5	11.5
14	....	2.5	5.0	6.0	7.0	8.0	9.0	11.0
16	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
18	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5

(For intermediate sizes use the voltages corresponding to the next larger size, having the same thickness of insulation.)

TABLE VI.

TEST POTENTIALS, KILOVOLTS

		Thickness of Insulation, 64ths Inch								
		12	14	16	18	20	22	24	26	28
250,000 and larger	Rubber	19	22	24	26	28	30	31	33	34
	V. C. or Paper	17	20	23	25	28	31	33	36	38
1-0000 A. W. G. or B. & S.	Rubber	18	21	23	25	27	28	30	31	32
	V. C. or Paper	16	19	22	24	27	30	32	34	36
4-2 A. W. G. or B. & S.	Rubber	17	19	22	24	25	26	28	29	30
	V. C. or Paper	15	17	20	23	25	28	30	32	34
6-5 A. W. G. or B. & S.	Rubber	16	18	20	22	23	25	26	28	29
	V. C. or Paper	15	17	19	21	23	26	28	30	31

TABLE VII.

MEGOHM-MILES AT 15.5° C. (60° F.) BASED UPON THE CONSTANT 4,000

1 Minute Electrification.

Rubber, minimum shall be 100% of following.
Varnished Cloth, minimum shall be 15% of following.
Impregnated Paper, minimum shall be 12½% of following.

Size of Conductors	Thickness of Insulation, 64ths Inch														
	2	3	4	5	6	7	8	10	12	14	16	18	20	22	24	26	28
2,000,000 C. M.	....	....	....	....	....	....	200	275	325	425	....	....	....	....	....	....	....
1,750,000	....	....	....	....	....	....	275	300	375	450	....	....	....	....	....	....	....
1,500,000	....	....	....	....	....	....	300	325	400	475	....	....	....	....	....	....	....
1.250,000	....	....	....	....	....	....	325	375	425	500	575	....	....	....	....	....	....
1,000,000	....	....	....	....	....	300	350	400	475	550	625	....	....	....	....	....	....
750,000	....	....	....	....	....	325	400	475	525	625	700	775	....	....	....	....	....
500,000	....	....	....	300	375	400	475	575	675	750	850	900	....	....	....	....	....
350.000	....	....	....	350	425	475	525	675	775	850	950	1050	1125	....	....	....	....
250,000	....	....	....	400	475	575	625	725	875	1000	1100	1200	1275	....	....	....	....
0000 A. W. G. or B. & S.	....	....	....	450	550	600	650	800	950	1050	1150	1250	1350	1450	....	....	....
000	....	....	....	500	600	650	750	850	1000	1150	1250	1350	1450	1550	....	....	....
00	....	....	....	550	650	750	850	950	1050	1250	1350	1500	1600	1700	1800	....	....
0	....	....	....	600	700	800	950	1050	1200	1350	1500	1600	1700	1800	1900	2000	....
1	....	....	600	650	750	850	1000	1150	1350	1450	1600	1750	1850	1950	2050	2150	2250
2	....	....	650	750	850	950	1050	1250	1450	1600	1700	1850	1950	2100	2200	2300	2400
4	...	....	750	850	1000	1150	1250	1450	1650	1850	2000	2150	2250	2400	2500	2600	2700
6	....	....	850	1050	1200	1350	1450	1750	1950	2100	2300	2450	2550	2700	2800	2900	3000
8	...	850	1050	1250	1450	1650	1750	2050	2200	2400	2600	2750	2900	3050	3150	3250	3350
10	....	1150	1350	1600	1800	2000	2150	2400	2650	2900	3100	3250	3400	3550	3700	3800	3900
12	....	1350	1600	1850	2050	2250	2400	2750	3000	3250	3400	3600	3750	3900	4050	4150	4300
14	....	1550	1850	2150	2350	2550	2650	3050	3350	3550	3800	3950	4100	4300	4400	4550	4650
16	1400	1800	2150	2400	2650	2850	3050	3400	3650	3950	4150	4350	4500	4650	4800	4900	5050
18	1600	2050	2450	2800	3000	3200	3400	3750	4050	4300	4500	4700	4900	5000	5150	5300	5400

The compound will be analyzed by the procedure of the Joint Rubber Insulation Committee current on the date of order.

Note—The limit on total surphur may be omitted by the purchaser if he desires to admit sulphur bearing fillers. See Report of Joint Rubber Insulation Committee, Proc. A. I. E. E. January, 1914.

(c) **Concentric Application:** The conductor shall be tinned. The compound shall be applied concentrically about the conductors and shall fit tightly thereto. Where the insulation is applied in more than one layer, adjacent layers shall cohere firmly. If necessary, in order to achieve this result on insulated conductors of greater diameter than 0.3 of an inch over the insulation, a tape shall be applied over the insulation before vulcanization. Such tape, if it does not comply with the tape specification given hereinafter, will be additional to any which may be required in the accompanying wire specification.

(d) **Tensile Strength and Elongation:** A sample which may be of entire, segmental, or approximately rectangular cross-section, at the discretion of the manufacturer, shall be cut from the insulated conductor by means of a sharp knife. The sample shall be bent in every direction to magnify and reveal any surface crack or imperfection which may exist. A portion of the sample without such defects and having a free length of not less than two inches, shall then be stretched at the rate of twelve inches per minute, until it breaks. The marks shall be placed on the insulation before its removal from the conductor. Five samples taken at random from every 25,000 feet or less shall be tested in this way. Tensile strength and elongation shall be made on unstretched samples.

The samples shall conform to the following limits:

TABLE VIII.

Property	Thickness Inches			
	12/64-in. or less		Over 12/64-in.	
	Maximum	Minimum	Maximum	Minimum
Tensile strength lbs. per sq. in. (each sample)...	....	1,000	....	1,000
Elongation in two (2) in. length at break (times original length)	....	5	....	4
Elongation 5 seconds after release when stretched at the rate of 12 in. per minute to 3 times its length	20%	....	20%	....

(e) **Electrical Tests:** Electrical tests shall be made upon rubber insulated wire or cable after at least twelve hours' immersions in water, while still immersed and before the application of any tape, braid or compound other than the tape used in vulcanization. The insulated conductor shall successfully meet the high potential tests specified in Tables V and VI. In the case of multiplex cables, the high potential test shall be made and the insulation resistance shall be measured before assembling the conductors. An additional electrical test shall be made on lead covered or armored cable and shall consist of a high potential test to be made upon the cable after assembling and leading or armoring and, if lead covered, without immersion in water. In the case of multiplex cables, this test shall be made successively between each conductor and the other conductors and sheath in multiple.

The insulation resistance shall be not less than specified in Table VII.

The insulation resistance (megohms) shall be reduced to that at 15.5 deg. cent. (60 deg. Fahr.) by multiplying by the coefficient in Table IX corresponding to the temperature at the time of test.

Varnished Cloth Insulation.

7. (a) **Description:** The insulation shall consist of a closely woven cotton cloth and a viscous filler. Each surface of the cloth shall have a smooth, continuous film of varnish and shall be free from wrinkles, blisters and all other imperfections. It shall be thoroughly impregnated with insulating compound, shall be pliable and shall have no tendency to crack when doubled on itself.

(b) **Filler:** The filler shall be a viscous, moisture-repelling insulating compound, having a dielectric constant similar to that of the varnished cloth insulation and of such a nature as to have no deleterious effect upon the varnish. It shall prevent the tapes from unwrapping when cut, but allow the layers to slide upon each other when the cable is bent.

(c) **Assembly:** The insulating cloth shall be applied in the form of tape wound on helically and reversed at least every two layers. The tapes shall be of such widths for different diameters of cable that they will lie smoothly and be free from wrinkles; the turns shall overlap and the joints in successive layers shall be staggered. The filler shall be so applied between layers as to exclude all air, the whole forming a hard, semi-flexible wall of insulation.

(d) **Tape:** A layer of cloth tape thoroughly filled with a rubber compound shall be applied over the cloth insulation. In the case of multiple conductor cables, a tape shall be applied over the assembled conductors or over the belt, if any. The tape shall comply with the requirements of section 10.

TABLE IX

(Tests shall be made at temperature within the scope of this table.)

Temperature Cent. Degrees	Coefficient	Temperature Degrees Cent.	Coefficient
7	0.65	16	1.02
8	0.69	17	1.08
9	0.73	18	1.12
10	0.77	19	1.18
11	0.81	20	1.23
12	0.85	21	1.30
13	0.89	22	1.37
14	0.93	23	1.43
15	0.98	24	1.49
15.5	1.00	25	1.56

(Tests shall be made at temperatures within the scope of this table.)

Temperature Degrees Fahr.	Coefficient	Temperature Degrees Fahr.	Coefficient
46	0.69	60	1.00
47	0.71	61	1.03
48	0.73	62	1.05
49	0.75	63	1.08
50	0.77	64	1.11
51	0.79	65	1.14
52	0.81	66	1.17
53	0.83	67	1.20
54	0.85	68	1.23
55	0.88	69	1.26
56	0.90	70	1.30
57	0.92	71	1.33
58	0.94	72	1.37
59	0.97	73	1.40
60	1.00	74	1.44
		75	1.48

(e) **Electrical Tests:** Each and every length of wire or cable shall meet the specified electrical tests. Wire or cable to be covered with dry or flameproof braid shall be tested after twelve hours immersion in water and before the braid is applied; if it is to be covered with weatherproof braid, the tests shall be made on the finished product. Lead covered conductors shall be tested against the sheath with sheath grounded. Multiplex cables shall be tested between each conductor and the other conductors and sheath or ground in multiple.

(f) **Temperature Coefficient:** The insulation resistance shall be not less than specified in Table VI. The insulation resistance shall be reduced to that at 15.5 deg. cent. (60 deg. Fahr.) by multiplying by the coefficient in Table X corresponding to the temperature at the time of test.

TABLE X

(Tests shall be made at temperatures within the scope of this table.)

Temperature		Coefficient	Temperature		Coefficient
Degrees Cent.	Degrees Fahr.		Degrees Cent.	Degrees Fahr.	
4.5— 7.2	40—45	0.50	16.1—18.3	61— 65	1.4
7.7—10.1	46—50	0.67	18.8—21.1	66— 70	2.0
0.5—12.7	51—55	0.83	21.6—23.8	71— 75	2.5
13.3—15.5	56—60	1.00	24.4—26.6	76— 80	3.3
			27.2—29.4	81— 85	5.0
			30.0—32.2	86— 90	6.7
			32.7—35.0	91— 95	10.0
			35.5—37.7	96—100	20.0
			38.3—40.5	101—105	33.3

Impregnated Paper Insulation.

8. (a) **Description:** The insulation shall consist of a manila paper applied helically, firmly and evenly to the conductor, and then thoroughly impregnated with an insulating compound. The cable shall be pliable and shall show no tendency to harden injuriously at 0 deg. cent.

(b) **Paper:** The paper shall contain no free acids or free alkalis. Tensile strength tests shall be made upon paper taken from the finished cable, both from conductor and jacket, if any. Test pieces five feet in length shall be selected, looped and tesion applied at the loop through a mandrel, one inch in diameter.

A tension of 5,000 pounds per square inch shall be applied for five minutes, and then 6,500 pounds per square inch for one minute.

If more than one out of six samples selected from each lot by the inspector fails to meet the tests, the entire lot may be rejected.

(c) **Compound:** The compound shall be applied so as to exclude all air and moisture and shall contain no free mineral acid or other substances which have a deleterious effect upon paper.

(d) **Electrical Tests:** Each and every length of finished cable shall conform to the specified electrical tests. No immersion is required before testing. The potential test shall be made between conductor and sheath with the sheath grounded. Multiple conductor cables shall be tested between each conductor and sheath or ground, in multiple. Immediately upon the receipt of an order (not a bid) the manufacturer shall submit a table of temperature coefficients which shall be used to reduce the measured megohms to the standard temperature.

Braids.

9. (a) **Description:** Braid shall be closely woven of cotton thread, at least two-ply, thoroughly impregnated with an insulating waterproof compound and finished with a black insulating compound thoroughly slicked down. The compound shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 90 deg. cent. (194 deg. Fahr.). The thickness shall be not less than given in the following table:

TABLE XI

Diameter Over the Insulation, Inches	Thickness of Braid, Inches, Not Less Than
.160	.018
.290	.028
.530	.038
1.000 and over	.053

For intermediate diameter use next smaller diameter.
Note.—The above does not apply to fancy or special braids for fixtures, etc.

(b) **Tests:** A six-inch sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20 deg. cent. (68 deg. Fahr.) and for a period of twenty-four hours. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent of the weight exclusive of copper and insulation before submersion. The compound shall not drip at a temperature of 50 deg. cent. (122 deg. Fahr.).

TABLE XII

Diameter Over Insulation Inches	Maximum Width of Tape, Inches	Minimum Overlap Inches
2.00	5	½
1.75	4—½	½
1.50	4	½
1.25	3—½	½
1.15	3—¼	½
1.00	3	½
.88	2—¾	⅜
.75	2—⅜	⅜
.62	2	⅜
.44	1—¾	⅜
.38	1—½	¼
.31	1—¼	¼
.25	1	¼
.19	⅞	⅛
.16	¾	⅛

For intermediate diameters use next smaller diameter.

Rubber Filled Cloth Tape.

10. The tape shall consist of a cotton cloth not lighter than one pound per four yards 36 inches wide with not less than 56x60 picks per inch, thoroughly filled with a rubber compound. The tape shall be applied helically, overlaping not less than specified in Table XII which also gives the maximum width of tape allowed:

Sheath.

11. (a) **Thickness:** Unless otherwise specified, the sheath shall have an average thickness of not less than that indicated in Table XII, and the minimum thickness shall in no place be less than 90 per cent of the required average thickness.

TABLE XIII

	Corresponding Thickness of Sheath in Inches	
Diam. of Core, Inches	Paper Insulation	Rubber or Var. Cloth Insulation
—0.29	5/64	4/64
0.30—0.69	6/64	5/64
0.70—1.24	7/64	6/64
1.25—1.99	8/64	7/64
2.00—2.69	9/64	8/64
2.70—over	10/64	9/64

For intermediate diameter use next smaller diameter.

(b) **Composition:** The sheath shall consist of commercially pure lead for all cables having a core diameter (i. e., internal diameter of the sheath) less than two inches; for cables having a core diameter equal to two inches or more the sheath shall consist of an alloy of commercially pure lead and commercially pure tin containing not less than one per cent of tin.

Wire Armor.

12. (a) **Armor:** The core of the cable shall be run through a hot asphalt compound, served with a layer of jute yarn, run through hot asphalt compound, armored with galvanized wire, run through hot asphalt compound, served with a layer of the best three-ply 14-pound hard twisted jute yarn with a close short lay, run through hot asphalt compound, served with a second layer of three-ply, 14 pound jute yarn, run through hot asphalt compound and finished by running through some material to prevent sticking. If the cable is rubber insulated, it shall be covered with tape, braid or other suitable protection before passing through the asphalt compound.

(Under certain conditions, the purchaser may find it advisable to specify the omission of the outer jute coverings.)

(b) **Size of Armor Wire:** The proper size of armor wire will depend upon the conditions of service; the latitude allowed in the following table represents the difference arising from such difference in service conditions. Unless otherwise specified, the armor wire shall be the minimum size.

TABLE XIV

Diameter of Cable Under Jute Bedding, Inches	Armour Wire Steel Wire Gauge*	Jute Bedding Under Armour Measured in Finished Cable, Inches
0.00—0.50	14—13	2/32 minimum
0.44—0.69	12	2/32
0.63—1.00	10	2/32
0.88—1.50	8	2/32
1.25—2.00	6	2/32
1.30—larger	4	2/32

*The same number wire on the Birmingham Wire Gauge will be acceptable. The Steel Wire Gauge is desired in Circular No. 31 of the Bureau of Standards, the corresponding diameters being as follows:

Steel Wire Gauge No.	Diameter, Mils
14	80.0
13	91.5
12	105.5
10	135.0
8	162.0
6	192.0
4	225.3

(c) **Lay:** The armor shall be applied closely without appreciable space between adjacent wires. The lay shall be from eight to twelve times the pitch diameter.

(d) **Direction of Lay:** Successive layers of jute or jute and armor shall be laid in opposite directions. In the case of multiple conductor cable armored without lead, the outside layer of conductors shall be put on with a right hand lay. The armor shall be put on with a left-hand lay.

(e) **Armor Wire:** The armor wire shall consist of a galvanized mild steel wire of uniform diameter, free from all cracks, splits or other flaws. Samples shall be taken (at random) from 10 per cent of the coils to be used for each of the following tests. At least 80 per cent of the samples shall fulfill the conditions of the test in order that the whole lot may be considered satisfactory.

(f) **Tensile Strength Test:** The wire shall have a tensile strength of not less than 50,000 pounds per square inch and an elongation of not less than 10 per cent in eight inches.

(g) **Galvanizing Test:** Thoroughly clean a sample to remove all dirt and grease, rinse in clean water and wipe dry with a clean cloth or cotton waste. Immerse for one minute in a solution of copper sulphate of specific gravity 1.186 at 18.3 deg. cent. (65 deg. Fahr.), rinse in clean water and wipe dry. Repeat this operation until the samples have been immersed four times. After these immersions no sample shall show any bright deposit of copper. The samples shall be approximately straight and the ends protected with parraffin. The solution shall be saturated with copper sulphate to which an excess of C. P. cupric oxide has been added and shall be maintained at 15.5-20 deg. cent. (60-68 deg. Fahr.) during the test. In case of failure of only one sample in a group of seven samples immersed together, or if there is a reasonable doubt as to the copper deposit, two check tests shall be made on these seven wires. If there is more than one failure in the original test, or if either check test shows any failures, the lot may be rejected.

(h) **Flexibility Test:** The armor wire shall admit of bending around a spindle of ten times the diameter of the wire and back again without developing cracks of the galvanizing which are visible to the naked eye.

Steel Tape Armor.

13. (a) **Description:** The core of the cable shall be run through a bath of hot asphalt compound, served with a layer of jute yarn spun on with a close, short lay, run through hot asphalt compound, armored with a steel tape; armored with a second steel tape, run through hot asphalt compound, served with a layer of three-ply, 14-pound jute yarn with a close, short lay, run through hot asphalt compound and finished by running through some material to prevent sticking. Both steel tapes shall be laid in the same direction and the outer shall be centered over the spaces between turns of the inner. If the cable is rubber insulated, it shall be covered with tape, braid or other suitable protection before passing through the asphalt compound. Each layer of jute shall be applied in the reverse direction to the adjacent layer. The space between adjacent turns of steel tape shall be ten per cent of the width of the steel tape. A three per cent variation either way, will be allowed.

(b) **Armor Tape:** The galvanized tape and the jute, under the armor, after armoring, shall conform to the requirements of Table XV.

TABLE XV

Cable Diameter Before Armoring, Inches	Maximum Width Steel Tape, Inches	Minimum Thickness Each Tape, Inches	Minimum Jute Bedding Under Armor Measured in Finished Cable, Inches
—0.45	½	0.02	2/32
0.46—0.75	¾	0.02	2/32
0.76—1.00	1	0.03	2/32
1.01—1.40	1¼	0.03	2/32
1.41—1.70	1½	0.04	2/32
1.71—2.00	1¾	0.04	2/32
2.01—over	2	0.05	2/32

Cable Reels.

14. (a) **General:** Each reel shall consist of a wooden drum with wooden discs or heads securely fastened thereto.

(b) **Bushings:** Each disc or head of the reel shall be provided with an iron plate or cast iron bushing in the center of which shall be a hole two and one-half inches in diameter. The plates or bushings shall be secured to the head by means of bolts or lags through the head.

(c) **Covering:** Insulated cable shall be thoroughly covered with burlap before lagging is applied.

(d) **Lagging:** When used for insulated cable the reels shall be suitably lagged; when used for bare cable, the lagging of the reel shall be replaced by a burlap covering securely bound to the cable.

(e) **Chocking:** Reels shall be properly chocked in the car so that there shall be no movement of reels during transit.

Part IV--A. I. E. E. Stan. Rules

Terminology*

Wire.—A slender rod or filament of drawn metal. The definition restricts the term to what would ordinarily be understood by the term "solid wire." In the definition, the word "slender" is used in the sense that the length is great in comparison with the diameter. If a wire is covered with insulation, it is properly called an insulated wire; while primarily the term "wire" refers to the metal, nevertheless when the context shows that the wire is insulated, the term "wire" will be understood to include the insulation.

Conductor.—A wire or combination of wires not insulated from one another, suitable for carrying a single electric current. The term "conductor" is not to include a combination of conductors insulated from one another, which would be suitable for carrying several different electric currents.

Rolled conductors (such as busbars) are, of course, conductors, but are not considered under the terminology here given.

Stranded Conductor.—A conductor composed of a group of wires, or of any combination of groups of wires. The wires in a stranded conductor are usually twisted or braided together.

Cable.—(1) A stranded conductor (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable). The component conductors of the second kind of cable may be either solid or stranded, and this kind of cable may or may not have a common insulating covering. The first kind of cable is a single conductor, while the second kind is a group of several conductors. The term "cable" is applied by some manufacturers to a solid wire heavily insulated and lead-covered; this usage arises from the manner of the insulation, but such a conductor is not included under this definition of "cable." The term "cable" is a general one, and, in practice, it is usually applied only to the larger sizes. A small cable is called a "stranded wire" or a "cord," both of which are defined below. Cables may be bare or insulated, and the latter may be armored with lead, or with steel wires or bands.

Strand.—One of the wires, or groups of wires, of any stranded conductor.

Stranded Wire.—A group of small wires, used as a single wire. A wire has been defined as a slender rod or filament of drawn metal. If such a filament is subdivided into several smaller filaments or strands, and is used as a single wire, it is called a "stranded wire." There is no sharp dividing line of size between a "stranded wire" and a "cable." If used as a wire, for example in winding inductance coils or magnets, it is called a stranded wire and not a cable. If it is is substantially insulated, it is called a "cord," defined below.

Cord.—A small and very flexible cable, substantially insulated to withstand wear. There is no sharp dividing line in respect to size between a "cord" and a "cable," and likewise no sharp dividing line in respect to the character of insulation between a "cord " and a "stranded wire." Rubber is used as the insulating material for many classes of cords.

Concentric Strand.—A strand composed of a central core surrounded by one or more layers of helically-laid wires or groups of wires.

Concentric-Lay Cable.—A single-conductor cable composed of a central core surrounded by one or more layers of helically-laid wires.

Rope-Lay Cable.—A single-conductor cable composed of a central core surrounded by one or more layers of helically-laid groups of wires. This kind of cable differs from the preceding in that the main strands are themselves stranded.

N-Conductor Cable.—A combination of N conductors insulated from one another. It is not intended that the name as here given be actually used. One would instead speak of a "3-conductor cable," a "12-conductor cable," etc. In referring to the general case, one may speak of a "multiple-conductor cable" (as in definition §638 above.)

N-Conductor Concentric Cable.—A cable composed of an insulated central conducting core with (N—1) tubular stranded conductors laid over it concentrically and separated by layers of insulation. This kind of cable usually has only two or three conductors. Such cables are used for carrying alternating currents. The remark on the expression "N-conductor" given for the preceding definition applies here also.

Duplex Cable.—Two insulated single-conductor cables, twisted together. They may or may not have a common insulating covering.

Twin Cable.—Two insulated single-conductor cables laid parallel, having a common covering.

Triplex Cable.—Three insulated single-conductor cables twisted together. They may or may not have a common insulating covering.

Twisted Pair.—Two small insulated conductors, twisted together, without a common covering. The two conductors of a "twisted pair" are usually substantially insulated, so that the combination is a special case of a "cord."

Twin Wire.—Two small insulated conductors laid parallel, having a common covering.

SPECIFICATION OF SIZES OF CONDUCTORS

The sizes of solid wires shall be stated by their diameter in mils, the American Wire Gage (Brown and Sharpe) sizes being taken as standard. The sizes of stranded conductors shall be stated by their cross-sectional area in circular mils. For brevity, in cases where the most careful specification is not required, the sizes of solid wires may be stated by the gage number in the American Wire Gage, and the sizes of stranded conductors smaller than 250,000 circular mils (i. e., No. 0000 A. W. G. or smaller) may likewise be stated by means of the gage number in the American Wire Gage of a solid wire having the same cross-sectional area. Furthermore, an exception is made in the case of "Flexible Stranded Conductors," for which see §655 below. In **stating large cross-sections,** it is sometimes convenient to use a circular inch (507 sq. mm.) instead of 1,000,000 circular mils.

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*From Circular No. 37 of the Bureau of Standards.

Stranding.

Cables not requiring special flexibility shall be stranded in accordance with the following table.

TABLE XVI

Standard Stranding of Concentric-Lay Cables

SIZE	Number of Wires		
	A	B	C
(See Note 1)	Bare Cables for AERIAL USE[*]	Weatherproof Cables for AERIAL USE[*]	Insulated Cables
2.0 Cir. Inches	91	91	127
1.5	61	61	91
1.0	61	61	61
0.6	37	37	61
0.5	37	37	37
0.4	19	19	37
0000 A. W. G	7	19	19
00	7	7	19
2	(See Note 2)	(See Note 2)	7
9	(See Note 2)	(See Note 2)	(See Note 2)

(1) For intermediate sizes, use stranding for next larger size.
(2) Solid Wire is recommended.

[*] Tentatively adopted pending ratification by other societies interested.

Sectional Area of Cables. The cross-sectional area of a cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

Flexible Stranding. Conductors of special flexibility should ordinarily be made with wires of regular A. W. G. sizes, the number of wires and size being given. The approximate gage number or approximate circular mils of such flexible stranded conductors may be stated. The following stranding table is suggested.

TABLE XVII

Proposed Standard Stranding of Flexible Cables[*]

Nearest A. W. G. Size (See Note 1)	Circular Mils	Number of Wires	Size of Each Wire A. W. G.	Make-up (See Note 2)
—	1,102,941	427	16	61x7
—	874,496	427	17	"
—	693,448	427	18	"
—	549,976	427	19	"
—	436,394	427	20	"
—	345,913	427	21	"
—	274,390	427	22	"
—	264,698	259	20	37x7
0000	209,816	259	21	"
000	166,433	259	22	"
00	135,926	133	20	19x7
0	107,743	133	21	"
1	85,466	133	22	"
2	67,764	133	23	"
3	53,732	133	24	"
4	39,695	49	21	7x7
5	31,487	49	22	"
6	24,966	49	23	"
7	19,796	49	24	"
8	15,700	49	25	Optional (See Note 3)
9	12,451	49	26	"
10	9,854	49	27	"
11	7,830	49	28	"
12	6,208	49	29	"
Smaller		To equal required size	30	Bunched

Note 1. The A. W. G. sizes are approximated within 5 per cent.

Note 2. 61x7 signifies a rope-lay cable composed of 61 strands of 7 wires each.

Note 3. Rope-lay or bunched.

[*] This table is offered for consideration but will not be recommended for final adoption until ratified by other societies interested. The addition of another Table giving a further degree of flexibility is under consideration. The stranding of No. 4 A. W. G. and smaller sizes, is particularly open for discussion.

Correction for Lay. The resistance and mass of a stranded conductor are greater than in a solid conductor of the same cross-sectional area, depending on the lay (i. e., the pitch of the twist of the wires). Two per cent shall be taken as the standard increment of resistance and of mass. In cases where the lay is definitely known, the increment should be calculated and not assumed.

The direction of the lay is the lateral direction in which the strands of a cable run over the top of the cable as they recede from an observer looking along the axis of the cable.

Conductivty of Copper

The following I. E. C. rules are adopted:[*]

The following shall be taken as normal values for standard annealed copper:

(1) At a temperature of 20°C., the resistance of a wire of standard annealed copper one meter in length and of a uniform section of 1 square millimeter is $1/58$ ohm $= 0.017241$ .... ohm.

(2) At a temperature of 20°C., the density of standard annealed copper is 8.89 grams per cubic centimeter.

(3) At a temperature of 20°C., the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is $0.00393 = 1/254.45$ .... per degree centigrade.

(4) As a consequence, it follows from (1) and (2) that, at a temperature of 20°C. the resistance of a wire of standard annealed copper of uniform section, one meter in length and weighing one gram, is $(1/58) \times 8.89 = 0.15328$......ohm.[†][§]

Copper Wire Tables. The copper-wire Tables published by the Bureau of Standards in Circular No. 31 are adopted. These Tables are based upon the I. E. C. rules stated in §675.

Heating and Temperature of Cables.

Maximum Safe Limiting Temperatures.

The maximum safe limiting temperature in degrees C. at the surface of the conductor in a cable shall be:—

For impregnated paper insulation (85—E)
" varnished cambric (75—E)
" rubber insulation (60—0.25E)

where E represents the r.m.s. operating e.m.f. in kilovolts between conductors.

Thus, at a working pressure of 3.3 kv., the maximum safe limiting temperature at the surface of the conductor, or conductors, in a cable would be:—

For impregnated paper 81.7°C.
" varnished cambric 71.7°C.
" rubber insulation 59.2°C.

Electrical Tests.

Lengths Tested. Electrical tests of insulation on wires and cables shall be made on the entire lengths to be shipped.

Immersion in Water.—Electrical tests of insulated conductors not enclosed in a lead sheath, shall be made while immersed in water after an immersion of twelve (12) hours, if insulated with rubber compound, or if insulated with varnished cambric. It is not necessary to immerse in water insulated conductors enclosed in a lead sheath.

In multiple-conductor cables, without waterproof overall jacket of insulation, no immersion test should be made on finished cables, but only on the individual conductors before assembling.

Dielectric-Strength Tests. Object of Tests.—Dielectric tests are intended to detect weak spots in the insulation and to determine whether the dielectric strength of the insulation is sufficient for enabling it to withstand the voltage to which it is likely to be subjected in service, with a suitable factor of assurance.

The initially-applied voltage must not be greater than the working voltage, and the rate of increase shall not be over 100 per cent in 10 seconds.

Factor of Assurance.—The factor of assurance of wire or cable insulation shall be the ratio of the voltage at which it is tested to that at which it is used.

Test Voltage.—The dielectric strength of wire and cable insulation shall be tested at the factory, by applying an alternating test voltage between the conductor and sheath or water.

The Magnitude and Duration of the Test Voltage should depend upon the dielectric strength and thickness of the insulation, the length and diameter of the wire or cable, and the assurance factor required, the latter in turn depending upon the importance of the service in which the wire or cable is employed.

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[*] See I. E. C. Publication No. 28 "International Standard of Resistance for Copper" March, 1914.

[†] Paragraphs (1) and (4) of §675 define what are sometimes called "volume resistivity," and "mass resistivity," respectively. This may be expressed in other units as follows:— volume resistivity = 1.7241 microhm-cm. (or microhms in a cm. cube) at 20° = 0.67879 microhm-inch at 20° C., and mass resistivity = 875.20 ohms (mile, pound) at 20° C.

[§] For detailed specifications of commercial copper, see the "Standard Specifications" of the American Society for Testing Materials.

The following test voltages shall apply unless a departure is considered necessary, in view of the above circumstances: Rubber covered wires or cable for voltages up to 7 kv. shall be tested in accordance with the National Electric Code. Standardization for higher voltage for rubber insulated cables is not considered possible at the present time.

Varnished cambric and impregnated paper insulated wires or cables shall be tested at the place of manufacture for five (5) minutes, in accordance with the Table XVIII below.

TABLE XVIII

Recommended Test Kilovolts Corresponding to Operating Kilovolts

Operating kv.	Test kv.	Operating kv.	Test kv.
Below 0.5	2.5*	5	14
0.5	3	10	25
1	4	15	35
2	6.5	20	44
3	9	25	53
4	11.5		

*The minimum thickness of insulation shall be 1/16 inch (1.6 mm.)

Different engineers specify different thickness of insulation for the same working voltages. Therefore, at the present time the test kv. corresponding to working kv. given in Table XIV are based on the **minimum** thickness of insulation specified by engineers and operating companies.†

The Frequency of the Test Voltage shall not exceed 100 cycles per second, and should approximate as closely as possible to a sine wave. The source of energy should be of ample capacity.

Where Ultimate Break-Down Tests are required, these shall be made on samples not more than 6 meters (20 ft.) long. The maximum allowable temperature at which the test is made for the particular type of insulation and the particular working pressure, shall not be greater than the temperature limits given in § 677.

Multiple-Conductor Cables.—Each conductor of a multiple-conductor cable shall be tested against the other conductors connected together with the sheath or water.

Insulation Resistance

Definition.—The insulation resistance of an insulated conductor is the electrical resistance offered by its insulation, to an impressed voltage tending to produce a leakage of current through the same.

Insulation Resistance shall be expressed in megohms for a specified length (as for a kilometer, or a mile, or one thousand feet), and shall be corrected to a temperature of 15.5° C. using a temperature coefficient determined experimentally for the insulation under consideration.

Linear Insulation Resistance, or the insulation resistance of Unit Length, shall be expressed in terms of the megohm-kilometer, or the megohm-mile, or the megohm-thousand feet.

Megohms Constant.—The Megohms Constant of an insulated conductor shall be the factor "K" in the equation

$$R = K \log_{10} \frac{D}{d}$$

where R = The insulation resistance, in megohms, for a specified unit length.

D = Outside diameter of insulation.

d = Diameter of conductor.

Unless otherwise stated, K will be assumed to correspond to the mile unit of length.

Test.—The apparent insulation resistance should be measured after the dielectric-strength test, measuring the leakage current after a one-minute electrification, with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained positive to the sheath or water.

Multiple-Conductor Cables.—The insulation resistance of each conductor of a multiple-conductor cable shall be the insulation resistance measured from such conductor to all the other conductors in multiple with the sheath or water.

Capacitance or Electrostatic Capacity.

Capacitance is ordinarily expressed in microfarads. Linear Capacitance, or Capacitance per unit length, shall be expressed in Microfarads per unit length (kilometer, or mile, or one thousand feet) and shall be corrected to a temperature of 15.5° C.

Microfarads Constant.—The Microfarads Constant of an insulated conductor shall be the factor "K" in the equation

$$C = \frac{K}{\log_{10} \frac{D}{d}}$$

where C = the capacitance in microfarads per unit length.

D = the outside diameter of insulation.

d = the diameter of conductor.

Unless otherwise stated, K will be assumed to refer to the mile unit of length.

Measurement of Capacitance.—The Capacitance of low-voltage cable shall be measured by comparison with a standard condenser. For long lengths of high-voltage cables, where it is necessary to know the true capacitance, the measurement should be made at a frequency approximating the frequency of operation.

Paired Cables.—The capacitance shall be measured between the two conductors of any pair, the other wires being connected to the sheath or ground.

Electric Light and Power Cables.—The capacitance of low-voltage cables is generally of but little importance. The capacitance of high-voltage cables should be measured between the conductors, and also between each conductor and the other conductors connected to the lead sheath or ground.

Multiple-Conductor Cables (not paired).—The capacitance of each conductor of a multiple-conductor cable shall be the capacitance measured from such conductor to all of the other conductors in multiple with the sheath or the ground.

W. A. Del Mar, Interborough Rapid Transit Co. Chairman.
A. Ames, Kerite Ins. Wire & Cable Co.
A. L. Crater, N. Y. C. & H. R. R. Co.
W. C. Hayman, General Electric Co.
R. W. Krass, New York Edison Co.
W. I. Middleton, Simplex Wire & Cable Co.
F. J. White, Okonite Co.

Committee on Industrial Trucks

Your Committee on Industrial Truck Standards in its first report submitted standards which were adopted by the Association on Capacity Rating, Speed Rating, and standard industrial truck voltage and standards for Tire Sizes. It has been ascertained that a number of tire companies are prepared to furnish the standards adopted by the Association, while the standards on capacity, speed and voltage have practically been made such by accepted practices and are in general use.

Your Committee has underway the matter of collecting outlines and principal dimensions of industrial trucks with the diameter of the path of wheels in rounding curves, with the thought that this information may be of interest in laying out runways in our railroad shops and freight stations. The information thus far received is not sufficiently complete to submit a report on the subject at the present time.

The subject of a standard motor outline for industrial trucks has received considerable thought and study on the part of your Committee and an endeavor will be made to arrive at a standard on this subject if it will be found possible to bring to a head the slight difference now existing in dimensions of industrial truck motors. A similar Committee is working in the Society of Automobile Engineers and it is expected that this Committee will have a report to make in January, 1916, and with the thought of your Committee co-operating with the Society of Automobile Engineers' Committee to the fullest extent possible on this subject that it will be better policy to await the action of the S. A. E. before proceeding to adopt standards by the A. R. E. E. With this thought, your Committee requests that it be continued another year.

T. V. Buckwalter,
Chairman, Industrial Truck Committee.

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†The Standards committee does not commit itself to the principle of basing test voltages on working voltages, but it is not yet in possession of sufficient data to base them upon the dimensions and physical properties of the insulation.

Standard Rules for Car Wiring

General.

Your committee presents a set of specifications which are intended to cover the complete installation of an electrical wiring system for the lighting of passenger cars that will meet the requirements of the Board of Fire Underwriters Rules.

It shall be understood and agreed with the car builders that these specifications shall be fulfilled in their true spirit and meaning, to the satisfaction of the electrical department of the railroad company and shall provide for a first-class and complete system of wiring in every respect. It shall be further understood and agreed that any apparatus or appliance essential to the safe, proper or convenient operation of the system shall be supplied and installed at cost, even though such appliance be not called for in these specifications.

The wiring shall be arranged for use in connection with Axle Driven—Volt Generator or Head End—Volt Generator operated in conjunction with a storage battery mounted under the car body. The wiring system shall be complete, including conduit, conduit fittings, outlet boxs, switches, cut-outs, fuses, sockets, fixtures, wires, cables, etc. The wiring shall be in accordance to prints approved by the railroad company.

The car builder shall furnish blue prints showing conduit plan, wiring diagrams and any other prints necessary for the application of electrical equipment. The car builder shall also furnish print of the details and application as he interprets the lighting arrangement and submit them to the railway company for their approval before starting work. A floor plan showing the location of lights shall accompany specifications of each class of car. An underframe plan showing location of equipment boxes and all other apparatus placed under car body shall be furnished. The car builders must in all cases ascertain for themselves that the specifications in their possession are of the latest revision. The railroad company shall specify under separate heading all materials used, showing catalogue number of fittings and equipment. The standard rules for car wiring of the A. R. E. E. shall govern the installation of conduit and wires on all cars, and are incorporated herein:

Standard Rules for Car Wiring

CW-1, 1915

Conduit and Fittings.

1. All wiring must be done in approved galvanized or sherardized steel conduit of sufficient size to allow for the pulling in freely of all wires after conduit is in place.
2. Conduit must be so arranged that wires can be renewed without necessitating the removal of the interior finish of the car.
3. Conduit and fittings to be firmly and substantially fastened to the frame-work of the car.
4. Fittings must be so installed that the covers will be accessible.
5. Ends of conduit must be cut square and reamed smooth and must be butted together in couplings.
6. No conduit smaller than ⅜-inch shall be used.
7. Where pipe threads are exposed they must be leaded and painted.
8. All conduit for circuit wiring must be run inside the car.
9. Conduit for generator leads shall run direct from the generator connector to the regulator locker and must not be less than 1¼ inches in size.
10. Conduit for battery leads and charging receptacles shall run to a junction box located near the battery box.
11. Conduit for battery wires shall run from a junction box located near the battery box direct to the regulator locker.
12. A junction box must be placed in the conduit where a reverse or double bend occurs or the run is too long to allow the wire to be readily fished through the conduit.
13. Junction boxes and outlet fittings exposed to the weather shall be of cast iron, to be made of one piece and have threaded hubs that shall engage at least five threads and have integral bushings.
14. The conduit must be so constructed as to form one perfect electrical conductor and this shall be connected by the ground clamp to the iron frame-work of the car.
15. Connection from conduit to ground must be exposed to view and readily accessible and must be made with a copper wire of at least No. 6 B & S gauge.
16. Light fixtures and fans must be either thoroughly insulated from or else solidly connected to the frame-work of the car and conduit system.

Generator Lead Connector.

1. A generator lead connector having no exposed live parts and so constructed that no tools will be necessary to make and break connections, and that the polarity cannot be reversed when the plug is inserted; to be used to connect the generator leads to the wiring on the car body.

Charging Receptacle.

1. A charging receptacle shall be placed on each side six inches back under the bottom of the car.
2. The receptacle must be designed so that the strain of the plug is taken on the frame of the receptacle and not on the contact parts of either plug or receptacle.
3. These receptacles shall be housed in swivel cast fittings with self closing doors.
4. Contact parts must have sufficient capacity to carry 65 amperes of current without temperature rise exceeding 15 degrees C.
5. Charging plug and receptacle must be interchangeable with the M. C. B. Standard.
6. The positive pole must be connected to the outside annular ring, negative pole to center post.

Wiring.

1. All wires and cables must be insulated with Grade "A" insulation according to specifications of the A. R. E. E., and must be double braided.
2. No wires smaller than No. 14 B & S gauge shall be used, except for fixture work, where No. 18 B & S gauge may be used.
3. Main circuit wires shall be at least No. 12 B & S gauge.
4. All wires of No. 8 or larger must be stranded.
5. Generator leads and train wires must be extra flexible as prescribed.
6. Slack in wires must be felt at all outlets and junctions.
7. No joints or splices will be permitted in conduit between junctions or fittings.
8. All joints in wires and cables must be so spliced or joined as to be both mechanically and electrically secure without solder.
9. All joints must be soldered.
10. The soldering flux must be free from acid.
11. The insulation on wires must be removed without marking or cutting the wire.
12. Care must be taken that no sharp point of wire or solder is left to pierce the insulation and cause a ground.
13. The joint must be covered with approved splicing tape of sufficient thickness to make the joint equal in insulation to the rest of the wire, this shall be covered with approved friction tape.
14. The generator leads from dynamo to the terminal connector on the car body shall consist of No. 4 B & S gauge extra flexible stranded (133 strands or more) conductor covered with grade "A" insulation and one linen braid saturated with weather-proof compound.
15. All generator leads to be enclosed in a canvas hose or equivalent protection.
16. The train connector cable to be of No. 2 B & S gauge extra flexible (133 strands or more) insulated with grade "A" insulation and covered with weather-proof braid or No. 2/0 B & S gauge flexible stranded (836 strands or more) covered with grade "A" insulation and weather-proof braid.
17. Battery connector cable must be No. 4 B & S gauge stranded (133 strands or more) insulated with grade "A" insulation but with no other covering.

Fuses and Cutouts.

1. Each circuit of the car wiring must be provided with an automatic fuse cut-out in each wire placed on the switchboard and the fuses in the same so proportioned that they will blow and disconnect the circuit before the wire becomes overheated.
2. The fuses protecting the generator shall be located

on the regulator panel and must be so connected that the blowing of the main generator fuse will disconnect the field circuit also.

3. The fuses protecting the batteries must be located in a substantial cast iron weather-proof fuse-box with hinged cover and substantial wing-hut catch just outside of the battery box, one at each battery terminal.

4. No taps for regulator wiring shall be connected on the lamp circuit outside of the fuse cutouts.

5. The table of "Allowable carrying capacities of wires" issued by the National Board of Fire Underwriters shall guide installation of all cutouts.

6. The terminal for reception of fuses on individual lamp and fan circuits must be of the "Edison" screw shell type.

7. The fuse terminal for axle generator field must be of the ferrule clip type with 1 in. clear space between clips.

8. The terminal for the main generator fuse must be of the knife blade clip type and have 4 in. clear space between clips.

9. The terminal for the battery fuses under the car must be of the knife blade clip type of 150 ampere capacity N. E. C. standard and have 4 in. clear space between clips.

10. On the switchboard, the battery, main light and train wire circuits must be each provided with terminals for reception of link or ribbon fuses 2½ in. between centers having wing nuts with washers for screwing fuse to strap.

11. Fuses may be omitted on the switchboard battery terminals.

12. All wires must be marked at the terminals for identification of polarity.

13. Positive terminal must be to the right when facing the apparatus or the upper when the terminals are in a vertical row.

Switchboard.

1. The switchboard must be made of one piece of oiled monson slate.

2. It must be so constructed that fuse cutouts and circuit switches can be removed or replaced without taking down the switchboard.

3. The main circuit switch must be placed on the switchboard and must be proportioned to the connected lead, but must be built for a minimum of 60 amperes capacity. This rule applies to train line switch also.

4. The main circuit switch and train line switch must be equipped with stamped open link fuses fastened with wing nuts.

5. The main circuit switch must control both sides of the circuit and must disconnect the car circuits and the lamp voltage regulator from the battery.

6. All connections on switchboard must be made with the positive to the right facing switchboard. When vertical mounting makes this impossible the top connection shall be positive.

Regulator Locker.

1. The regulator locker must be metal lined or constructed of steel not less than 12 in. in depth and 20 in. in width, 24 in. preferred, if possible.

2. Suitable locker space must be provided for the generator and lamp regulators, and for the car circuit switchboard.

3. The regulator shall be mounted on "Z" irons which must be securely fastened to the back of the locker by bolts where the construction permits and where screws are used they must be spaced not more than 4 in. apart.

4. The switchboard and regulator panels must be secured with ⅜ in. hex-head bolts which must be slotted for screw driver. The "Z" iron shall be tapped to take the standard ⅜ in. bolt.

5. The locker shall be ventilated entirely from within the car by means of openings at the top and bottom of the locker door.

6. Where the locker is built below the door level the bottom of the locker must be closed so that material or rubbish can not accumulate in it.

7. Where the door extends to the floor a false bottom shall be placed in the bottom of the locker at the angle of 45 degrees so that rubbish can not be swept into the locker. Under no circumstances will the mounting of the regulator below the level of the door opening be permitted.

8. A notice must be mounted in the switchboard locker giving the following information:

System.
Type of Generator.
Type of Regulator.
Number of cells in series.
Number of sets in parallel.
Ampere hour capacity (8 hour rate).
Normal Charging Rate.................. Maximum..................
Size of Train Wires.................. B & S gauge.
Number of train wires.
Ampere load—all lights (lights only).
Setting of axle generator..................Amperes.
Cut in voltage.
Voltage of lamps.
Amperes no light.
Amperes full load (Light and Battery).
Axle Pulley..........Diameter..........Face..........Bore..........
Generator Pulley..........Diameter..........Face..........Bore........
Length of Belt..................
Diagram of connections.

Fixtures.

1. The fixtures must be designed so as to be easily wired, all corners to be rounded off to prevent abrasion or cutting of the wires when they are pulled in.

2. A high grade heat resisting insulation must be used on all fixture wire and in the composition of the sockets.

3. In the construction of sockets nothing less than a standard ⅜ in. socket base, standard pipe threads and center spring contact must be used.

4. All fixtures of any certain design must have a standard base with holes bored to a template so that when the fixture is removed another of the same design can be put in its place without necessitating the boring of new holes.

Train Lines.

1. Cars operated on head end systems must be equipped with 3 train wires of 4/0 B & S gauge wire.

2. All cars equipped with train wires must be fitted with standard train line receptacle and connector.

3. If only two wires are used, they may be No. 2 B & S gauge, and the center connection is to be omitted. In this case the female receptacle is to be marked "NOT FOR USE ON HEAD-END SYSTEMS".

4. The train wire connector must be interchangeable with the No. 3 Gibbs connector and receptacle.

Generator and Suspension.

1. The generator shall be suspended so as to have not less than 1 in. clearance from brake rod and brake release springs which must permit ready inspection and repair to the generator.

2. There must be not less than 6 in. clearance between the generator and the track rail and not less than 5 in. between the top of the generator and the car body.

3. No apparatus, equipment or battery box must be placed within five feet of the generator.

4. The loop formed by the generator leads must not be less than eight inches above the rails.

5. The belt running over the end-sill and under the brake beam must have not less than 1 in. clearance from the same.

6. The belt must not run through a slot in the end sill.

7. If running over the brake beam, the belt must have at least 2 in. clearance from the same when the brakes are set.

8. Steam drips must be provided with drip shields extending to within 6 in. above the top of the rails.

9. The car builder must furnish an underframe plan showing location of all apparatus placed under the car body, with the clearance shown in detail.

10. All equipment must conform to the clearance adopted by the American Railway Association's diagram covering standard limits of clearance lines for third rail and rolling equipment. (See Circular No. 1192.)

11. The suspension parts must be securely bolted or riveted and must be firmly braced and secured either to the car body or the truck frame.

Battery Boxes.

1. Battery boxes must be installed under the body of the car, near the center and 6 in. back from the side.

2. The battery box supports must pass under the box so as to carry the weight of the batteries and be securely fastened and braced to the car body.

3. The battery box must be built so that it can be removed without removing the supports.

4. Clearance should conform to the requirements of the electric zone of the city of New York.

5. Battery boxes must be built of ⅛ in. steel divided into two compartments each having inside dimensions as follows: 21½ in. high, 28 in. deep and 45¼ in. long.

6. Each compartment must be lined with wood ¾ in. thick on top, sides, back and door, and applied so as to be easily removable.

7. The wooden bottom must be 1 in. thick and so ar-

ranged that it can be renewed without disturbing the rest of the wood lining.

8. The wood must be saturated with a composition of one part paraffine and one part beeswax or rosin.

9. Each compartment must be ventilated by four holes in the bottom of the box covered with wire netting, and a cast iron ventilated handle on each door.

10. The doors must open or close independent of each other.

11. The hinges and door fasteners must be heavy enough to carry the weight of the batteries and must be arranged so that door can be sealed.

12. A bar must be placed in front of the batteries so as to prevent them from moving. This bar must be easily removable for inspection of batteries.

Respectfully submitted,

Geo. B. Colegrove, Ill. Cent. Ry., Chairman,
F. J. Hill, Michigan Central.
L. S. Billau, B. & O. R. R.
S. W. Everett, Santa Fe.
E. E. Goddard, Penn. R. R.
R. Pachaly, Rock Island Lines.
J. L. Ohmans, Chicago & Western Ind.

Committee on Illumination

Your committee has confined its work to continuing its investigation of the subject of illumination of classification yards and has also prepared a brief resume of the development in incandescent lamps during the year.

Illumination of Classification Yards.

In the committee's report for last year the problems involved in adequate lighting of classification yards were described briefly. On account of the lack of reliable data, the rapid changes taking place in development of lighting units, etc., it was felt inadvisable to submit any recommendations until illumination tests could be made on an actual installation with various arrangements and types of modern lighting units. Plans were made to carry out such tests on a new installation to be made in a typical classification yard of one of the railroads. For unavoidable causes the installation of the lighting system was delayed until a short time ago with the consequence it has been impossible to secure the desired data in time to present at this meeting. Your committee decided it would be inadvisable to present its recommendations until completing the test data and therefore a report on this subject will be submitted later.

In connection with this work the committee is in touch with the Sub-committee on Classification Yards of the American Railway Engineering Association's Yards and Terminals Committee and has arranged to furnish them with the results of this Association's study of the yard lighting problem.

Developments in Incandescent Lamps.

In the incandescent lamp field improvements and changes during the past few years have been and continue to be so rapid that it is difficult for the average user of lamps to keep up with them. Your committee believes, therefore, it would be desirable that the Committee on Illumination, as a part of its regular work, keep in close touch with the development in incandescent lamps, especially where largely affecting the railway user, and present in its annual report at least an outline of the developments that have taken place during the year.

Since 1907 the sales in this country of Mazda lamps have been increased from 0.10% to 71% of total lamps sold, while that of carbon lamps has decreased from 93 to 7%, the remainder being practically entirely Gem lamps. With the decrease in price and increase in efficiency of Mazda lamps it is highly questionable today that there is any place in railway service where the use of carbon or Gem lamps can be justified with the exception of where mechanical breakage is excessive due to vibration or other causes.

During the past year development work has been principally along the lines of increasing the number of sizes of the Mazda C, or gas filled lamp bulbs. They are now commercially available in the multiple burning type from 1000 watts down to and including 100 watt size in the 110 volt class, and will probably soon include the 60 watt size, while in the 220 volt class they are available in sizes as small as the 200 watt lamp. On the other hand, the vacuum type of Mazda multiple burning lamps are no longer listed in sizes above 100 watts for the 110 volt class and 250 watts for the 220 volt class. Improvements have been made in securing a more uniform product, while their development has reached the stage where the bulb shapes and dimensions are practically standardized.

The development work in the Mazda C lamps for train lighting service has progressed to the point where they will soon be commercially available. In this connection there is the important question to be settled of the sizes that should be provided as it is highly desirable to avoid the multiplicity of sizes that railroads have been using in the vacuum type. This is a matter regarding which the Association should take formal action.

In the Mazda B or vacuum type lamp the improvements made have been almost entirely in increasing the efficiencies. These have amounted to approximately 6 to 9% and in a few sizes somewhat more. In the train lighting lamps the increase has been about 5% for the smaller sizes and 10% for the 40 watt size. The accompanying table shows in tabulated form the new Mazda lamps that have been introduced since October, 1914, as well as the changes in efficiencies that have taken place.

NEW MADZA LAMPS

October 1, 1914—July 1, 1915

Size	Volts	Type
	Multiple Burning, Mazda B	
7½ watt	105 to 125	Straight Side—Sign Lamp
25 "	"	" " Mazda B Coil
40 "	"	" " " " "
60 "	"	" " " " "
	Mazda C	
100 "	"	Pear Shape
200 "	220 to 250	" "
300 "	"	" "
300 "	"	" "
500 "	"	" "
750 "	"	" "
1000 "	"	" "

Size	Volts	Type
	Series Burning for Street Series Service	
100 c. p.	7.5 amp.	Straight Side, Mazda C
400 "	"	Pear Shape, Mazda C
600 "	"	" " " "
	Train Lighting Lamps	
75 watt	30-34 & 60 to 65	Round

CHANGES IN EFFICIENCY

October 1, 1914—July 1, 1915

Size	Volts	Type	Efficiency W. P. C. Old	Efficiency W. P. C. Present
	Multiple Burning, Mazda B			
10 watt	105 to 125	Straight Side	1.30	1.05
15 "	"	" "	1.25	1.10
20 "	"	" "	1.17	1 07
25 "	"	" "	1.14	1.05
40 "	"	" "	1.10	1.03
60 "	"	" "	1.07	1.00
100 "	"	" "	1.02	.95
15 "	"	Round	1.25	1.15
25 "	"	"	1.14	1.05
40 "	"	"	1.10	1.03
60 "	"	"	1.07	1.00
100 "	"	"	1.02	.95
25 "	"	Tubular	1.14	1.05
25 "	"	Straight Side	1.33	1.20
40 "	"	" "	1.28	1.12
60 "	"	" "	1.23	1.10
100 "	"	" "	1.12	1 00
150 "	"	" "	1.05	1.00
250 "	"	" "	1.00	.95
25 "	"	Round	1.33	1.20
40 "	"	"	1.28	1.12
500 "	"	"	1.10	.90
	Mazda C			
200 "	105 to 125	Pear Shape	.9	.75
300 "	"	" "	.85	.7
400 "	"	" "	.75	.7
200 "	"	" "	.8	.9
300 "	"	" "	.78	.85
750 "	"	" "	.60	.65
1000 "	"	" "	.55	.60

Size	Volts	Type	Efficiency W. P. C. Old	Present
	Series Burning for Street Railway Service			
23 watt	105 to 130	Straight Side	1.30	1.11
36 “	“	“ “	1.26	1.09
56 “	“	“ “	1.16	1.02
94 “	“	“ “	1.14	.97
	Series Burning for Street Series Service			
60 c. p.	5.5 amp.		.79	.78
80 “	“		.77	.74
100 “	“		.75	.72
250 “	“		.73	.68
400 “	“		.71	.68
60 “	6.6 amp.		.67	.78
80 “	“		.66	.74
100 “	“		.65	.71
250 “	“		.63	.65
400 “	“		.61	.64
600 “	“		.61	.64
60 “	7.5 amp.		.67	.78
80 “	“		.66	.74
100 “	“		.65	.71
250 “	“		.63	.63
400 “	“		.61	.62
600 “	“		.61	.62
400 “	15 amp.		.54	.50
600 “	20 “		.50	.47
1000 “	20 “		.50	.47
	Train Lighting Lamps			
15 watt	25 to 34 & 50 to 65		1.17	1.12
20 “	“ “ “ “ “		1.15	1.10
40 “	“ “ “ “ “		1.10	1.00

Recommendations.

With the rapid development in incandescent lamps involving, in some cases, radical changes, new problems are constantly arising affecting the rating, testing of lamps, etc. Your committee therefore recommends that the Committee on Illumination of the Association of Railway Electrical Engineering include each year as a part of its regular duties the following:

1st—Co-operation with other associations and the lamp manufacturers with reference to revision of standard incandescent lamp specifications, submitting at each annual meeting such revision as may have been found desirable due to progress of the art.

2nd—Important changes it may be desirable to make in train lighting, headlight, or other types of lamps used practically exclusively by steam railroads, should be brought to the attention of the Association for its recommendations by the lamp manufacturers. Such matters would be gone into by the committee taking them up with the various railroads and lamp manufacturers or whatever course of action might be necessary to secure the views of the lamp users.

Respectfully submitted,
Committee on Illumination:
L. S. Billau, B. & O. R. R. Chairman.
C. W. Bender, Nat'l Lamp Works of G. E. Co.
L. C. Doane, Holophane Works of G. E. Co.
H. C. Meloy, New York Central (Lines West.)
J. L. Minick, Penn. R. R.
G. O. Moores, B. & O. R. R.

Committee on Standardization of Crane Motors

Study of Existing Conditions

This committee was originally instructed to investigate and report on the subject of standardization of motors for shop traveling cranes and also for turn and transfer tables. But after a preliminary investigation, it was decided that the work involved in obtaining something in the way of standardization of shop traveling crane motors alone, would require all of the time at the disposal of your present committee. Therefore, the latter two subjects will not be discussed in this report.

From the 1914 report of the Committee on Data and Information, it was clearly shown that the present shop traveling crane equipment is in a rather chaotic condition so far as any attempt at standardization or uniformity of motor size is concerned. The information obtained by this committee from the various railroads fully corroborates the information compiled by the previous committee.

Crane Capacities.

From the information furnished by the various railroads it is found that between the capacities of 1 ton and 150 tons, there are 25 different crane sizes of shop traveling cranes employed, which are as follows:

1, 1¾, 2, 3, 4, 5, 6, 7½, 10, 12, 15, 20, 25, 30, 40, 50, 65, 75, 80, 90, 100, 120, 125, 130, 150.

Of course, many of these cranes are rather old and accordingly are either above or below the capacity required for their present work, but it is an unquestionable fact that railroad repair shop service does not represent any such a wide range of conditions as would require 25 different crane capacities.

Horse Power

In the matter of motor horse power for main hoist, bridge and trolley movements, for cranes of a certain capacity, the statistics furnished by different railroads again show a very chaotic condition, for instance, of the 108 10-ton cranes for which data has been compiled by your committees, there are 35 different motor sizes and combinations. There are 12 different motor sizes for the main hoist alone and a correspondingly wide variation in motor size for bridge and trolley movements.

While it may be held by some, that different motor sizes are required because of different operating conditions, any engineer who gives the matter a thought must realize that here lies some important work to be done in the way of standardization of motor sizes, so that future installations of shop traveling cranes equipment will be made on a uniform basis and the number of motor sizes be reduced to a minimum.

The gun shot diagrams, as shown in Figs. 1 and 2, show graphically the information furnished for two of the many sizes of cranes listed. In the one case are shown eleven 100-ton cranes and in the other case ...... 10-ton cranes, which can be taken as characteristic of all crane capacities. Each of the heavy crosses indicate the motor sizes and hoisting speed of one crane. It will be noted that there is a wide diversity of results which would indicate that either the hoisting speeds were taken when running light, that there was an error in taking the speed ratings, or what would seem to be more reasonable, that the cranes were greatly over-rated so far as the speed of operation was concerned, for 7 of the 10 cranes reported specified an operating speed not even theoretically possible with the size of motor employed. In case of three of these cranes, however, the overload rating of the

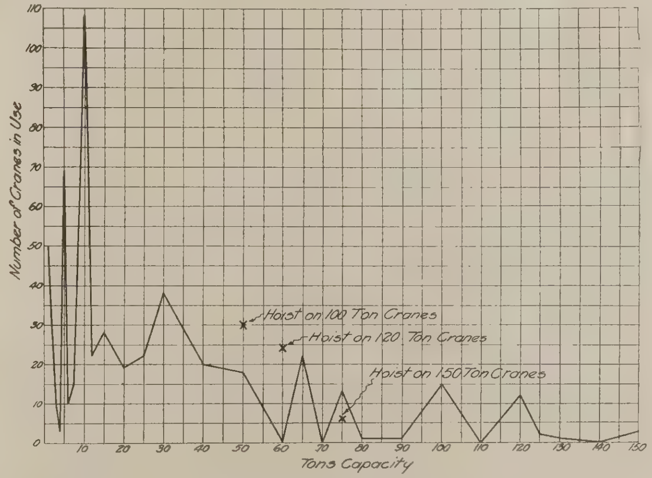

Fig. 1. Curve Showing Number of Cranes of Various Sizes Reported by Railroads

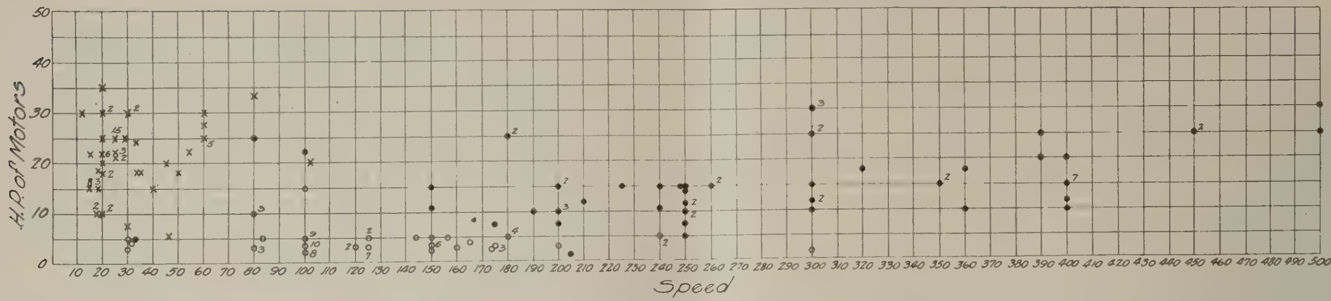

Fig. 2. Gun-Shot Diagram Indicating Motor Sizes and Operating Speeds for 10 Ton Cranes. "X" Indicates Hoisting Speed and Main Hoist Motor Size for a Certain Crane. "O" Indicates Trolley Motor Sizes and Speeds and Solid Circles Indicate Bridge Motor Sizes and Operating Speeds

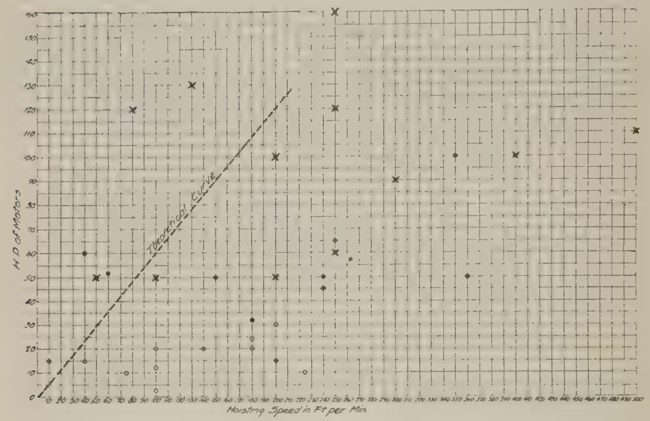

Fig. 3. Gun-Shot Diagram Indicating Motor Sizes and Operating Speeds for 100 Ton Cranes. The Key is the Same as Fig. 2, Except Main Hoist Speed is Multiplied by 10 in Plotting.

motor would easily take care of the difficulty, but it can be safely said that 4 of the 10 cranes reported are much overrated. The speeds and motor sizes for bridge and trolley movements show a correspondingly wide variation as will be noted from the diagrams.

It is hoped that the future work of this committee may form a logical basis which will materially assist railroad engineers in the selection of their crane equipment in the future.

Analysis of the Problem

It is needless to state that your committee has fully appreciated the great magnitude and likewise the importance of the work assigned to it in endeavoring to standardize on motor sizes for shop traveling cranes. This involves far more than might be thought for there are several other features regarding traveling cranes which must be standardized before it will be possible to arrive at any standards whatever in regard to motor sizes.

Crane Capacities

The first step is to standardize on such crane capacities as will fully meet the needs of the modern locomotive repair shop, and at the same time reduce the total number of different crane capacities to a minimum. After giving this subject very careful consideration your committee has to recommend nine crane sizes as follows:

2, 5, 10, 15, 30 (single and double trolley), 60, 75, 120 (double trolley), 150 (double trolley).

Moreover, the 30-ton, 120-ton and 150-ton cranes will each have a double trolley hoist so that the hoisting equipment covering all sizes of traveling cranes will be actually reduced to seven sizes as follows:

2, 5, 10, 15, 30, 60, 75.

Your committee realizes that there may be individual preferences on the part of many engineers for odd sizes of cranes, but it is no trade secret that odd crane sizes specified by railroad engineers usually are made up as a compromise equipment from a few standard sizes, and not always with the best results for either the crane manufacturer or the railroad company.

It would seem that these crane sizes recommended will readily take care of practically all conditions of shop operation as follows:—

2-ton crane for machine bays.
5-ton crane machine or erection bays, material yards, etc.
10-ton crane machine or locomotive bay, blacksmith shop, yard, etc.
15-ton crane, boiler shop.
30-ton crane, boiler shop.
120 and 150-ton crane (60 and 75-ton hoists) locomotive erecting bays.

This report does not attempt to cover the smaller classes of cranes, such as walking, jibs, "I" beam cranes, etc.

Operating Speeds

The operating speed of the main hoist bridge and trolley movements of the various sizes of cranes is the next step to be standardized on before standard motor sizes may be determined. Your committee has consulted every crane manufacturer known as such in the country, a list of approximately 20. Satisfactory information was received, however, from only four of the more important crane manufacturers and this is shown graphically in the accompanying diagrams, Figs. 3 and 4, the data furnished by each manufacturer being indicated by a different type of line. Fig. 3 shows the recommended speeds for the main hoist for various sizes of cranes. The "A" manufacturer, gave information as to high speed and low speed in addition to the medium speed shown. It was assumed, however, that on one hand the high speed data would apply to such traveling cranes as are used in steel mills, and on the other hand, the low speed data to

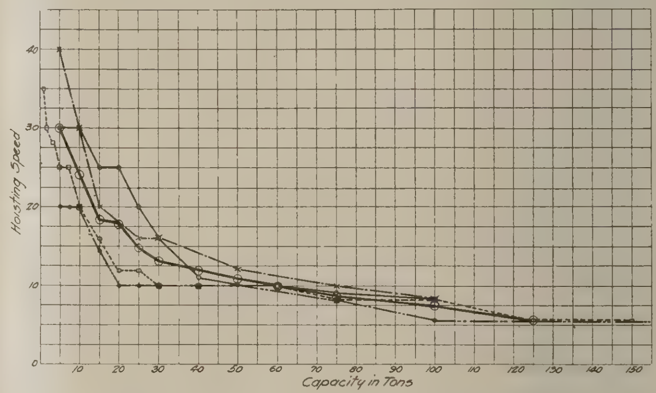

Fig. 4. Diagram Showing Main Hoist Operating Speeds Recommended by Four Manufacturers for Various Sizes of Cranes. Heavy Solid Line Indicates Average.

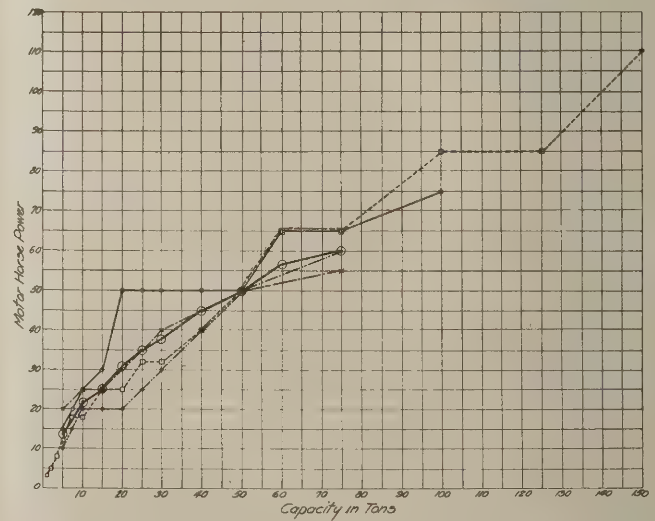

Fig. 5. Main Hoist Motor Sizes Recommended by Four Crane Manufacturers for Various Sizes of Cranes to Correspond with the Operating Speeds of Fig. 4.

such cranes as are used in storage yards, etc. So this data was eliminated and only the medium speeds given by this manufacturer were listed; this, however, checks reasonably well with the data received from the other manufacturers.

In considering this matter of speeds it must be realized that the operating speed at full load will depend altogether upon the size of the motor selected and where, as in the case of the "A" manufacturer, a 50 h. p. motor is used on 50, 40, 30, 25 and 20-ton cranes, the full load operating speed will be much higher in the smaller sizes than that of another crane manufacturer who has selected a motor more nearly in accordance with the capacity required for that crane. The heavy line curve shows the average of all speeds recommended and it should be noted that this follows very nicely to a hyperbolic curve which would be expected. Tabulating the data the average hoisting speed of all crane manufacturers' recommendations, is as follows:

Table I.

2 ton	35 ft. per minute
5 ton	30 ft. per minute
10 ton	25 ft. per minute
15 ton	20 ft. per minute
30 ton	20 ft. per minute
60 ton	8 ft. per minute
75 ton	7 ft. per minute
120 ton	8 ft. per minute
150 ton	7 ft. per minute

Bridge Traveling Speeds.

The speed at which the bridge of a crane should travel will, of course, depend largely upon the length of runway and here it is found that there exists a somewhat wider variation, due to local conditions, than in the case of the main hoisting speed. The bridge travel speed will vary not only with the length of runway, but also with the length of span, for this determines the total weight of the bridge, hence the operating speed for a given size motor. Manufacturers commonly employ a formula of 60 lbs. tractive effort per ton weight, this being made very liberal to allow for inaccuracies in the runway gauge, excess friction, etc.

Although complete information has not been received on this point from all the manufacturers, the data furnished for bridge traveling speeds is approximately as follows:—

Table II.

2 ton crane	150 to 300 ft. per minute
5 ton crane	300 to 350 ft. per minute
10 ton crane	250 to 300 ft. per minute
15 ton crane	250 to 300 ft. per minute
30 ton crane	200 to 250 ft. per minute
60 ton crane	150 to 200 ft. per minute
75 ton crane	150 to 200 ft. per minute
120 ton crane	150 to 200 ft. per minute
150 ton crane	150 to 200 ft. per minute

Trolley or cross trolley speed—
5 and 10 ton cranes, 125 to 150 ft. per minute.
15-30, 100 ft. per minute.
60-75 and 120-150, 80 ft. per minute.

Motor Sizes

The motor sizes recommended by four of the crane manufacturers for the various capacities of cranes are shown in Figs. 2, 3 and 4 and it will be noted that the motor sizes are in most cases simply a compromise, selecting the nearest standard size motor to the size required for operation at the specified speed. Here again the average of all motor sizes recommended is plotted as a heavy solid line and this will no doubt be an important factor in the further work of this committee in actually standardizing on motor sizes. Tabulating the data of one of the manufactures for main hoist motors we obtain the following table; this should not be taken, however, as a recommendation of the committee for further investigation may considerably alter the values:

Table III.

5 ton crane	14 horse power
10 ton crane	22 horse power
15 ton crane	25 horse power
20 ton crane	31 horse power
25 ton crane	35 horse power
30 ton crane	38 horse power
40 ton crane	45 horse power
60 ton crane	57 horse power
75 ton crane	60 horse power

Your committee, however, does not feel justified in making any definite recommendations as to motor sizes at present, but it is hoped that a further study into the problem will make it possible to standardize not only as to motor sizes, but as to motor outline, base templates, motor shafts and keyways. The standardization of motors should be accomplished in conjunction with representatives of the motor manufacturers so as to avoid destruction of present designs whenever possible. The great advantage of such standardization in crane motors is at once evident, for it would then be possible to reduce the number of spare motors, armatures, etc., carried in stock to a minimum, and in case of an emergency, it would be possible to install a crane motor of any make temporarily at least, in place of a corresponding size motor on any type of crane. It is recommended that this committee be continued for another year in order to allow this work to be carried to a successful conclusion.

Respectfully submitted,
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J. E. Gardner, C. B. & Q. R. R.
A. J. Farrelly, C. & N. W. Ry.
Edward Wray, *Rrailway Electrical Engineer.*
C. J. Causland, Pa. R. R.
P. L. Batty, Arnold Company.
R. M. Gaston, Geo. P. Nichols & Bro.
B. F. Bilsland, General Electric Co.

Committee on Compressed Air Generation

Upon a survey of the use of compressed air in railroad shops, your committee has come to the conclusion that the subject naturally divides itself under two heads: (1) The generation of power; (2) the means of utilizing the compressed air power generated with a view to comparing the utility of compressed air tools with those of electric driven tools.

Your committee finds, however, that the time available permits only a discussion of the subject of compressed air generation at this time and suggests that the further subject of the uses and abuses of compressed air in shops, terminals and yards, and the comparison of electric and air driven tools, be referred to a future committee.

There are two primary factors governing the selection of power for driving air compressors in railroad shops or terminal plants.

(a) The cost per indicated horse power or kilowatt for steam, electric or modern oil engine power, delivered to the piston rods of the compressor pistons.

(b) Cost of distributing mains and laterals, or in other words, all parts of the compressed air plant except the compressing unit.

Under the first factor, we have to consider, first, the cost of installation, cost of operation, maintenance, depreciation and the fixed charges. Under the second factor, we have the overhead charges to consider, also the center of demand, line loss, etc.

In figuring the cost of steam for steam driven compressors, we must figure that in the majority of plants, oftentimes practically the entire boiler output is required in the winter time for the production of heat. This meaning largely plants in that part of the country which have at least a month or more of winter weather. It is therefore necessary to have these boilers whether the air compressor is driven directly by steam or not, even though the air compressor is located only a short distance from the company's power plant, and there is a loss in converting the steam energy into electric power and again converting the electric power into air power, in fact it is probable that more loss would be experienced than with a properly designed distribution system. This is especially so, since even with a small compressor it is necessary to run a large number of small pipes and these are the most expensive part of the distributing system.

Comparison of Systems.

For purposes of illustration, we will work out three typical installations; one where a motor driven compressor would be advantageous; one where an oil engine driven compressor would be advantageous, and one where a steam driven compressor would be advantageous, thereby endeavoring to show an approximate line-up covering the installation of air compressors. In many instances where the installation would not be entirely typical for any one class of driven compressors, it is very probable that a few local conditions would turn the tide directly in favor of one or the other. This, of course, would have to be worked out by the engineer who is making the plans for the installation.

Taking it for granted that the steam is properly and economically produced in a railroad shop or terminal power plant, we will follow the distribution of the steam through the various classes of equipment, thus showing what proportion of the total steam production charges can be justly apportioned to the cost of air production, after other devices of any description, using steam, have been considered; this, of course, including steam heat, which is one of the most difficult charges to take care of.

Next, we will figure the efficiency or efficiencies of various types of steam driven compressors. Some of these compressors are very efficient, running up to 88 per cent efficiency; other compressors are very inefficient. I have known compressors that could only produce their rated output by running away over their rated speed, in fact a speed which would endanger life and property. The machine and the design of the machine was such that steam would be used for the entire length of stroke, which would cause a waste of from $10.00 to $15.00 per shop day on fuel. The steam end cylinders, clearances, ports and valve designs have an important bearing on the cost of production; likewise the air end, especially as regards valve design and clearances.

We will take it for granted that the moving parts and main bearings, valve motion gear, etc., are properly designed to give efficient and continuous service, as we must not lose sight of the fact that continuity of service is as desirable as is efficiency.

Steam Driven Compressors.

In figuring a typical design of steam driven air compressor, it is the intention to figure a high class machine.

In figuring an air compressor driven by an electric motor, we will also consider a high class efficient compressor, driven preferably by a three phase induction or synchronous motor, taking into consideration the load factor and going into a detailed discussion of unloading devices versus change of compressor speeds to meet the varying load conditions.

The air compressor driven by an oil engine might well prove typical to a large railroad yard located at some distance from the steam driven compressor plant, where there would be no cheap available electric current. This engine would be, preferably, of the Diesel type.

The distribution system can be made very expensive or it can be made fairly inexpensive by a proper design and layout of the system.

In most of the railroad shop plants, the steam driven compressors would show a saving in first cost and operation over motor driven compressors. This is due to the fact that the power plant is generally situated as near as possible to the center of demand, and oftentimes your main air line would be only some 500 feet or 600 feet in length, and practically all the other smaller pipe would be required even were you to use a motor driven compressor located in the shop proper, such shop space, of course, being very valuable.

It is on the long runs where a motor driven compressor may prove efficient, providing the cost of current is very low. However, against this we must figure that it has been feasible to pump compressed air at 100 pounds to 120 pounds pressure some several miles before it was used, possibly reheating a couple of times on the way. The reheating of air on long runs possesses a great deal of value.

Economics of the Compression of Air

In many respects, the operation of compressing air is similar to that of pumping water, inasmuch as the work is done, or should be done, against a fixed resistance, the speed of the compressor or pump, being varied in order to meet the volumetric requirements while maintaining a constant head of pressure. Having a constant load which requires a constant point of cut-off in the steam cylinders, we have a most favorable existing condition for obtaining a high steam economy. This fact makes it possible to so proportion the steam cylinders that we are able to utilize the most economical degree of expansion. The above should not be lost sight of when desiring to purchase an efficient compressor.

It has long been the practice for purchasers to demand efficient pumps for water systems. Probably one reason for this is the fact that it is very easy to check up the fuel consumption and cost of a water pumping system, as the input and output are very easily measured. Water pumping engines must of necessity be operated at piston speeds of from 200 feet to 300 feet per minute on account of the inelasticity of the fluid pumped. Air compressors can very safely operate at piston speeds of from 500 feet to 600 feet per minute; hence require only approximately one-half the cylinder dimensions necessary for a water-pumping engine. From this it is evident that we can secure high economy in an air compressor at a much lower cost than we can secure high economy in a water-pumping engine of the same power.

The probable reason that practically no attention has been paid to the purchasing of efficient air compressors is due to the fact that the use of compressed air by railroads has grown very rapidly, and that the air compressor is generally only a part of the power plant at a shop or terminal, and no careful attention has been given same to ascertain whether the compressor was efficient and consuming the proper power input, or whether it was costing twice or three times what it should; likewise, little effort has been given to secure proper and efficient operation of compressors. Each and every individual case should be studied by a competent engineer in order to ascertain whether or not in that particular case the efficient compressor would be a condensing, non-condensing, cross compound, poppet valve or Corliss valve.

Instances are known where well designed single expansion engines, operating compressors, require less steam than some compound engines. Likewise the term, "two stage" compressors, is very often only a "catch word." A two stage air compressor requires a low pressure cylinder large enough to take in the whole volume of air to be compressed, a high pressure cylinder and an intercooler between the cylinders with pumps and pipes for circulating cooling water through same. This complicates the compressor and adds quite materially to the first cost and operation of same.

The economy obtained by a properly designed two stage compressor is effected by minimizing the extra power made necessary for the compression by the heat generated during the operation. If, immediately after leaving the compressor, and before the heat of compression has been dissipated, the air could be used for developing power there would be no demand for any device to cool the air during compression; the use of such device merely resulting in a loss of efficiency. However, in railroad shops and terminal plants, this is not possible; hence, the necessity of cooling the air as much as possible during compression, especially with the larger machines. However, as air is one of the most perfect non-conductors of heat, and the time in which compression stroke is made is very short, it is impossible to effect an interchange of any considerable quantity of heat between the cooling medium and the air. In order to secure a sufficiently long time period in which to effect this interchange the two stage compressor with intercooler is designed. In order to secure this increased efficiency, it is necessary that the cylinders be very carefully proportioned for the existing compression ratio. The intercooler must be very carefully designed, and the valve area, air passages and clearances must be very carefully worked out.

From the above it will be seen that in the small capacity compressor it is necessary to figure the fixed charges on that part of the equipment made necessary by the use of the two stage. so that it can be compared to the small saving thereby effected in the compression. In the larger compressors, this comparison is not necessary, due to the increased unit efficiency of compression.

The best practice in designing air compressors, requires that all air cylinders be efficiently water-jacketed on barrels as well as on heads in all compressors where the air is to be compressed to over twice its original density.

The so-called "Corliss valve," which is a cylindrical rocking valve, is the most typical for air or gas distribution, when properly proportioned and constructed. This, of course, holding good in instances where the air or gas to be compressed is reasonably free from grit. Practically all atmospheric air is free from grit, if good judgment is used in locating the end of the intake pipe. The operation of these valves is simple and positive, being operated much in the same manner as the exhaust valves of the Corliss engine. It is, therefore, possible to use this valve and drive in all cases where the valve must be open during more than one-third of the stroke. From this it is evident that this type can be used in all cases for suction valves, except in cases of gritty gas, which would cut the valve and seat.

This type of valve is suitable for discharge valves in one, two or three stage compressors, in which it is necessary to keep valve open during approximately one-half of the stroke, except that in single stage compressors compressing to more than thirty pounds above the atmosphere, where the time between opening and closing is too short; in this case, self-acting poppet valves should be used for discharge valves. Self-acting poppet valves are most suitable for both suction and discharge valves, when gritty gases have to be compressed.

The positively operated discharge valve is most efficient on compressors in which the speed is automatically controlled to meet the air demand. This, if the compressor plant is properly designed for a load, will insure the proper operating against a constant head, the constant head being necessary to insure the efficient operation of the valve. The constant head is also necessary to secure anything like efficiency from the various tools that are being driven by this compressed air. It would therefore seem that the positively operated discharge valve is the proper valve for a well designed and efficient air system, except where compressors run at constant speed.

In the majority of railroad shops and terminals, this important feature has been entirely lost sight of, viz., the fact that to secure efficient operation of the entire air plant, it is necessary that it be operated at the constant head or pressure for which it was designed, which is in the majority of cases at the present time approximately 100 pounds.

The operation of the compressor engine, as regards condensing or non-condensing, is governed by the same rules as govern any steam engine; likewise the steam jacketing of cylinders in large units.

Comparison of Efficiency of Motor Driven, Steam Driven and Oil Engine Driven Compressors.

The efficiency of a well designed motor driven compressor is approximately 88 per cent. Mechanical efficiency of the belt driven compressor, 94 per cent. Efficiency of belt drive, 98 per cent. Motor efficiency, 90 per cent. Indicated horse power input to motor for, say, 100 theoretical air H. P. equals

$$\frac{100}{.88 \times .94 \times .98 \times .90} = 138 \text{ I. H. P.}$$

an overall efficiency of 72.5 per cent.

The efficiency of the same type of air compressor, steam driven, would be equal to 77.7 per cent, with an input of 128 H. P. per 100 theoretical air H. P.

The efficiency of the same type of air compressor oil engine driven would be equal to 81.3 per cent, with an input of 123 H. P. per 100 theoretical air H. P.

Comparison of Costs for Various Types

Steam Driven Compressors.

A well designed steam driven 3,000 cubic foot compressor will cost approximately $13,000 at the factory. This is a very satisfactory size of machine for a large railroad shop or terminal where the main engine room is located near the center of load demand, and especially so where the power house is a composite one, supplying live steam to shops, round houses, etc., and furnishing steam for electric generating units, pumps, compressors, etc.

For a 50 pit locomotive shop, it would require approximately 1,400 I. H. P. for air compressors, and the same for electric generators, with a possible 700 H. P. for pumps, round house steam, etc. With the boiler H. P., as generally figured, compared to I. H. P., we should then have all the exhaust steam needed for heat during the winter months.

A power plant of this description should be able to furnish a steam H. P. at a cost equal to at least $0.008 per K. W. hour at the switchboard, without deducting the charges for the steam heating. When the steam heating charges are deducted, a K. W. hour charge of from $0.006 to $0.007 should be secured.

The first cost and installation of a sufficient number of motor driven compressors scattered through the shop at the various centers of load demand, would be highly in excess of the steam driven plant, and the difference in cost of piping would be more than offset by the greater efficiency of the steam driven units coupled with the labor, cost of operating and maintaining; likewise this shop is not suitable for an oil engine driven compressor.

Motor Driven Compressors.

A well designed motor driven 1,000 cubic foot compressor will cost approximately $3,200; motor for driving same, $2,000.

A shop which requires but very little live steam in its operation, probably due to the fact that there is no round house operated in connection with same, and in which little steam is required for heating, but where electric current can be purchased for a price, say, in the neighborhood of $0.01 per K. W. hour, would be very well adapted to the installation of two or three motor driven compressors, according to the center of demand.

Where motor driven compressors are used, it is often of great advantage to use a synchronous motor. These give excellent service on units from 200 cubic feet to 1,200 cubic feet per minute; in fact, several compressors have been built having a capacity of 7,500 cubic feet per minute, driven by 1,200 H. P. synchronous motors. In such cases as these, or in cases where the compressor runs at a constant speed, a constant head of pressure is maintained by use of the valve gear and unloading device, in order that it may be able to deliver a variable quantity of air, depending upon the demand. This device should be such that it holds the intake valves open, thereby no air is compressed and no heat is generated in the cylinders, until the demand causes valves to operate in order to furnish some air to the line. This very greatly reduces the power consumption when the compressor is running idle.

In large constant speed compressors, driven by oil engines, gas engines, electric motors or water wheels, the unloading or reloading should be accomplished by degrees to prevent the objectionable large sudden changes in load to the power system. This necessitates some well designed form of variable capacity valve gear, the governor of which affects the power and output of the compressor similarly to the Corliss engine governor, which affects a gradual change of point of cut-off and the power developed.

The throttling inlet should not be used for the reason that it causes the compressor to use almost as much power when running at zero capacity as it does when running full capacity; hence, much is wasted. There is also danger of explosion, due to the constant churning and heating of the air in the cylinders. In constant speed compressors, the poppet discharge valve should be used, for the reasons previously stated.

Oil Engine Driven Compressors.

The oil engine driven compressor is most suitable at isolated points, such as a large terminal yard, or some small special shop where there is no demand for steam, except possibly such as can be furnished by the low pressure steam heating boiler and where the cost of electric current makes its use prohibitive. It is preferable to belt the engine to the compressor.

A 600 cubic foot compressor would cost approximately $1,700 at the factory. The 120 H. P. oil engine for driving same would cost approximately $6,000, a total first cost at the factory of $7,700.

As above stated, it would be necessary for the engineer to figure the cost of installation and fixed charges in each individual case in order to arrive at the proper conclusion.

The best type of compressor to be driven by an electric motor or an oil engine is one designed to operate at a constant speed, with the proper form of valve gear and unloading device, as this prevents complication of electric motor speed variation and the oil engine speed variation.

In the above report, the figures have been based on approximately 19 H. P. input for 100 cubic feet per minute rating, when compressing to 100 pounds gauge.

Respectfully submitted,
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H. R. Bucks, O. S. L. R. R.
L. C. Hensel, Frisco Lines.
J. F. Gardner, C. B. & Q. R. R.
F. G. Baker, Frisco Lines.
H. C. Meloy, Chairman, N. Y. Central (Lines West).

New C. M. & St. P. Electric Locomotive

It will be remembered that in December of this year we described in these columns, the electrification of the mountain division of the C., M. & St. P. between Harleton, Mont., and Avery, Idaho. The first locomotive which has been completed by the General Electric Co. is being taken West preparatory to being put into service and is being exhibited at various points en route. On October 6th, it was the good fortune of the people in Chicago to be able to view this largest electric locomotive in the world.

On entering either end of the locomotive one first passes by the operator's control and then directly into the compartment, where there is placed a large motor generator set which drives the large ventilating fans for cooling the main motors and for furnishing low tension direct current for the control apparatus. In the central compartment of each locomotive the remote control, high voltage relays are placed. These are arranged compactly so that they may be inspected from either a center aisle or two passages extending along both sides of the car. At the inner end of the car the lightning arresters and air compressors are located.

A complete description of this locomotive will be published in our November issue.

Committee on Shop Practice

The committee has decided to confine its efforts this year to certain individual subjects rather than endeavoring to cover the entire subject of electrical equipment in railroad shops. The subjects of crane magnets, magnetic chucks and furnaces, both electric and gas for tempering tools.

Crane Magnets.

In railroad work, the field of application of crane magnets is rather limited. They are at the present time used principally in scrap yards, around store-room platforms, etc., where it is necessary to handle iron and steel rapidly and economically. For this class of work, magnets are generally used in connection with locomotive cranes, making a self-contained, self-propelled unit which may be operated over shop and yard tracks as required. The use of this combination has reduced very greatly the cost of handling both new and scrap material, both by reducing the actual expense of handling and by enabling the material to be handled much more rapidly. In this connection a few examples may be cited. One road has handled with a locomotive crane and magnet 41 tons of old locomotive grates in 40 minutes, 56 tons of old track spikes in 33 minutes and 44 tons of miscellaneous scrap in 35 minutes. Another road is handling this class of material at a cost of less than $0.02 per ton as compared with $0.25 to $0.35 by hand. A road using four cranes, three equipped with magnets and one with a clam shell bucket, is handling scrap at $0.05 per ton. Specific figures given by one road are as follows:

Kind of Scrap.	Crane Cost.	Hand Cost.
No. 1 wrought iron	$0.04	$0.22
Busheling, No. 2 wrought iron, and malleable iron	.02	.10
Cast iron and mixed steel	.02	.09
Sheet steel	.20	.30

On some roads where traffic is very dense, a locomotive crane with magnet is used to pick up and load scrap along the line. The scrap, consisting of old rails and other track supplies, is collected and put into small piles along the track by the section gangs; a locomotive crane with a magnet is then sent over the line in a work train, thus handling the scrap cheaply and rapidly.

In shop work, cranes are also used to a limited extent, for handling parts such as car-wheels, castings, etc.

As can be seen from the foregoing, crane magnets will be used on outdoor work practically altogether. This requires that the construction of the magnet be such as to be unaffected by weather conditions, as reliability is a prime factor in economical operation. The failure of a magnet will, in most cases, seriously cripple the section of the yard where it is in use. All of the manufactures of magnets now on the market have apparently taken this point into consideration and are using very rugged construction, so that the magnets are practically indestructible.

Another very important point in magnet construction is that of insulation; due to self induction the voltage impressed on the magnet may, at the time the circuit is opened, rise to four or five times normal, thus setting up stresses which may break down the insulation in case it is in any way defective. In some makes of magnets this inductive discharge is shunted through a resistance, by means of suitable contacts in the controller. This is a desirable feature as it eliminates the high voltage and reduces the strain on the coil insulation.

Direct current is, of course, essential to the operation of crane magnets. They are usually wound for 220 volts, although 110 volt magnets may be obtained. The operation of magnets from 550 volt circuits is not recommended, due to the high voltage induced at the time the circuit is opened, even when discharge resistance is connected in circuit.

The controllers used in connection with crane magnets are of simple construction. They may be either of the magnetic or of the drum type. Three operating points are usually provided, these points being—"lift," "drop" and "off." When the control handle is placed in the lifting position, the magnet is connected across the line thus energizing it and enabling it to pick up the desired material. When the handle is thrown to the drop position, the current through the magnet is reversed, thus giving an instantaneous rerelease and effecting a slight saving in time by eliminating the sluggishness of release which is sometimes found when handling pieces which completely span the magnetic poles, or parts consisting of hard steel which retains a considerable amount of residual magnetism. In the off position, the magnet is dead.

The controllers are usually arranged so that the handle will not remain on the "drop" point, a spring being provided which throws the handle to the off position as soon as it is released by the operator.

Where magnets are used in connection with travelling or locomotive cranes operated by direct current, power can, of course, be taken from the crane supply circuit. On steam operated locomotives cranes, a small engine or turbine driven generator supplies the necessary direct current for the magnet, although power may in many cases be taken from a shop circuit through receptacles located at convenient points. Where the area to be covered by the crane is small, the connection to the supply circuit can often be made permanent, a flexible cable of suitable length being used.

The life of this cable, as well as of that connecting the magnet to the controller, may be materially increased by the use of some automatic device for taking up slack. One manufacturing company builds a simple motor driven take-up, which has proved very satisfactory in operation.

In general, the information obtained indicates that the cost of maintenance on crane magnets is practically negligible and consists, in most cases, simply in the renewal of cable. Where power for operating the magnet is supplied by generating equipment mounted on the crane, there will be also some slight maintenance expense for this apparatus. The simpler construction of the small steam turbines driven set as compared with engine driven equipment would seem to make the former somewhat preferable, as requiring less attention. This is especially the case in view of the fluctuating nature of the load on the generator.

In addition to the circular type, which is in most general use in railroad work, other forms of magnets are obtainable, arranged for handling special material. Among these types are the flat magnet for handling plates, the bi-polar type for handling rails, rods, pipes, etc., also magnets with specially shaped pole pieces for handling material such as car-wheels. However, the circular magnet will be found the most generally useful and it will take care of practically any class of work.

The use of magnets undoubtedy constitutes the simplest and cheapest method of handling iron and steel, and your committee suggests that the members of our association familiarize themselves with this class of apparatus, with a view to applying it to a greater extent than has been the case up to the present time.

Magnet Chucks.

From the information obtainable, it appears that magnetic chucks are being used in railroad shops to a very limited extent. In most cases they are installed in tool rooms, for handling comparative light work.

Tow general types of magnetic chucks are on the market, these types being known as flat and rotary respectively. The first of these is used with planers, millers or other machines, such as reciprocating grinders. Where necessary, chuck units can be placed end to end to accommodate long work.

Rotary chucks are of the same general design as the flat type, but are arranged for mounting on lathe spindles, boring mill beds, etc., so that cylindrical grinding or machine work can be done on work held by the chuck.

The field of magnetic chucks is principally in connection with grinding operations, either flat or cylindrical, although they are occasionally used for light machining operations, such as are performed on lathes, millers or planers. Their greatest merit lies in the fact that by their use light thin work may be supported rigidly without distortion due to clamps. This enables machining or grinding to be done to very close limits, and much more rapidly than where it is necessary to set up clamps to hold the work.

Where a large number of small duplicate pieces is to be finished by grinding or machining, the magnetic chuck furnishes a very economical method of supporting the parts while the work is being done.

The construction of magnetic chucks is important, as it is essential that they be of rugged construction and also that the insulation of the magnet coils and other current carrying parts be of the very best. The chuck as a whole should be water-proof so that wet grinding can be done without injury to the chuck. Most of the manufacturers of this class of apparatus are producing chucks which will meet these requirements.

The power reqiured for magnetic chucks is small and if the shop lighting or power circuits are direct current, the chucks can, in most cases, be connected directly to these shop lines. In all except the largest sizes, the required current can be taken from any convenient lamp socket. The chucks are obtainable wound for 110 or for 220 volts and in most cases they can be reconnected for either voltage without difficulty, in case necessity arises.

A demagnetizing switch is of great assistance in removing work from the magnetic chuck, for even after power has been shut off there will be a certain amount of residual magnetism between the poles of the chuck and the work. The demagnetizing switch eliminates this trouble and enables the work to be easily lifted from the chuck. These switches are double-throw, the chuck being energized in one position of the switch and demagnetized in the other position, the demagnetization being accomplished by reversing the current through the chuck. The switch is usually thrown from the demagnetizing to the off position by means of a spring arranged so that the contacts will not remain closed when the handle is released by the operator.

When demagnetizing work, a certain amount of care must be used by the operator, as if he keeps the demagnetizing contacts closed long enough to allow magnetism to build up to full strength in the opposite polarity, the chuck will continue to hold the work and the work itself will be found to retain as much residual magnetism as before.

Such classes of work such as hard steel parts will retain a small amount of residual magnetism which in some cases is objectionable. For removing this residual magnetism a demagnetizer may be used. This demagnetizer consists of a "U" shaped core energized by a coil through which alternating current is passed. The work to be demagnetized is passed over the ends of the core several times and when slowly removed, when it will be found neutral. Where alternating current is not available, direct current can be used in a demagnetizer which differs from the one mentioned in the foregoing in that an interrupter or some other device is provided for reversing the current through the demagnetizing coil.

Tempering of Tools.

Dies—Reports from four different sources show it is the general practice on this road to purchase dies for a small diameter bolt, as a rule ½" size, and as they become worn they are softened, bored, rethreaded and retempered for the use on ⅝" size bolts. They are again used until worn down so not fit for further use and again pass through the same process as before increasing them to the next larger size. These several processes are carried on until the stock of the dies are so much used up it is impossible to go through with another, which usually ends when the dies have been worked up to 1" or 1⅛", thus the one dies serves during its life for the several sizes if it is properly worked and handled.

The softening and retempering are the part of the processes which determine the life of the dies and of which we are interested, it being understood that dies herein mentioned are of the solid type.

To soften them they are placed in the blacksmith's coal fire and heated to a bright red and then drawn out and laid aside to cool slowly. It is during this heating and retempering process that not only dies but all the tools hereafter mentioned are exposed to the chemical action of the sulphur and carbon from the coal or oil, and while they are being heated either for softening or tempering the underside which is most exposed to the main blast of the fire becomes heated faster than the top side, therefore, more exposed, and as they become hotter after the first heating the chemical composition of each die or tool would be changed or in other words it has deteriorated a certain per cent with reference to its first chemical value.

It is only the experienced eye that can detect the right color of the heated iron when it is time to withdraw it from the furnace before complete deterioration of the tools has taken place, that is, before the molecules have separated or, as we often hear it called, "burned."

These several points are mentioned herein to show that the human eye is then responsible for the great many tools sent back to the tool room in a spoiled condition, also to show whereby a mechanical or electrical device like the electric furnace is more dependable for such work than any human eye, although ever so conscientious, because being calibrated for a predetermined heat a die placed in the electric furnace will be heated throughout the entire stock and will lastly be chemically unchanged, which in turn means that nearly 100% of the dies returned to the tool room are still of the same value as new ones, while with the coal furnace process not any are equal to their first value either chemically or from a commercial standpoint.

This also brings up the point that not only the dies that are ruined by over heat are lost but that the time of the man that worked on them and the cost of air used with the furnace are also wasted, which again proves that the human efficiency is not equal to the mechanical.

Taps and Reamers—A large portion of the heretofore mentioned points are applicable to taps and reamers, except in some cases I find that these are reduced in size, but these are practically negligible because as a rule they are broken before being worn out to an extent to require new threads. However, there is one great disadvantage of the coal furnace with handling these tools, that is, when retempering them, unless great care is exercised, they will be crooked on account of cooling too quickly, which will be necessary in order to give them the proper hardness. This is usually done by dipping them in a bath of kerosene or in some places fish oil is used, while with the electric furnace it would not be of any advantage only to get an even heat; therefore, tools handled for retempering are exposed to the same defects with either furnace.

Machine Tools and Chisels—Unless great care is taken in tempering these tools by the use of either furnace they will chip off at the points on account of brittleness, due to uneven heating or due to chemical changes if worked in the coal furnace.

Costs—The costs herein used are an average obtained from several different shops taken independently of each other and then compiled and although an average is used in no cases were the limits of high and low costs greater or less than 10% from each other; therefore, should be quite correct. It will also be understood that costs of air are based on an electric driven blower current costing two cents per kilowatt hour and on such tools that will require more than one heat to work them this is taken into account per unit price each.

DIES

Size	Softening	Labor to increase size	Retempering	Total
½" to ⅝"	.0383	.10	.041	$.1793
⅝" to ¾"	.0378	.112	.04	.1898
¾" to ⅞"	.0371	.121	.04	.1981
⅞" to 1"	.0365	.142	.038	.2165
1" to 1⅛"	.031	.161	.038	.23
1⅛" to 1¼"	.031	.164	.038	.233

In making these figures, machinists' labor costs at 40c per hr. were used and the blacksmiths' labor at 39c per hr.

TAPS

Size	Softening	Labor of dressing	Retempering	Total
1⅛" to 1"	.0423	.123	.0542	$.2195
1" to ¾"	.041	.119	.0540	.214

REAMERS

Nothing obtainable on this.

MACHINE TOOLS

Size	Labor of dressing	Tempering	Total
Small	.0633	.043	$.1073
Large	.0825	.052	.1345

Very little information was obtainable on these.

CHISELS

Size	Labor of dressing	Tempering	Total
Small	.041	.032	$.073
Large	.063	.052	.104

The last two items are usually of the best steel and it is necessary to often make more than one heat to work them and some of the costs collected under the head of "Chisels" show considerable higher than this given.

Respectfully submitted,

D. C. Wilson, Chairman, U. P. R. R., Omaha, Neb.
W. E. Heald, B. & O. R. R., Baltimore, Md.
H. R. Bucks, O. S. L. R. R., Pocatello, Idaho.
Geo. H. Cravens, C. & C. Elec. Mfg. Co., Garwood, N. J.
J. M. Craig, Pennsylvania R. R., Altoona, Pa.
J. L. Hayes, S. B. A. L. R. R., Portsmouth, Va.
L. R. Pomeroy, U. S. L. & H. Co., New York, N. Y.
J. H. Bryan, W. E. & Mfg. Co., Pittsburgh, Pa.
A. L. Chapin, I. C. R. R., Chicago, Ill.

Shop Motor Section

Electrically Operated Coal Hoists

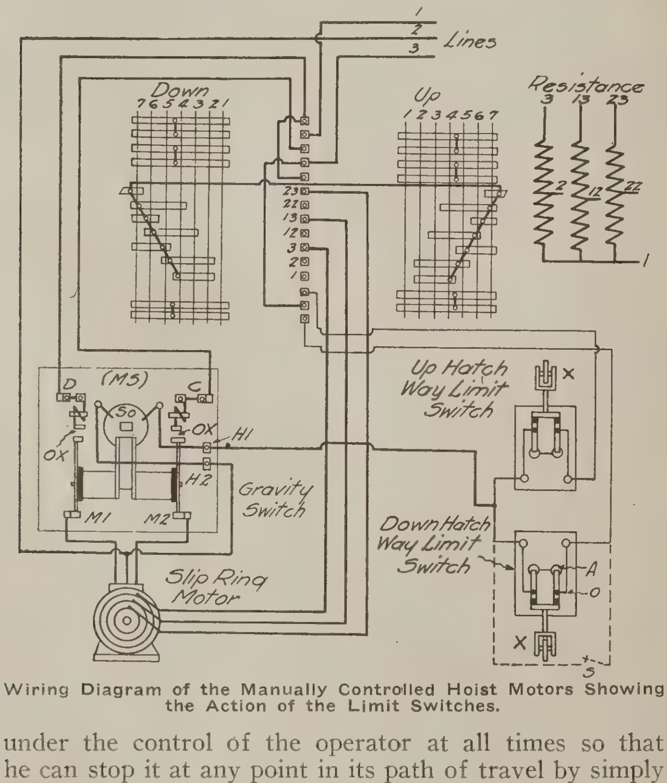
By J. H. Wickman

(Eleventh Article.)

In the September issue of the Railway Electrical Engineer three different types of electrically driven coal hoists were described. Two of these were of the manually controlled type and the third was an automatic hoist controlled by mechanical means.

Hand Controlled Electrically Driven Hoist.

Method No. 4.—This method differs from any of those previously described, in that it is more complete electrically. Figure 27 is a diagrammatic sketch of the electric features of this equipment. The coal bucket is under the control of the operator at all times so that he can stop it at any point in its path of travel by simply manipulating the drum controller, which is shown developed in the upper part of the sketch.



Wiring Diagram of the Manually Controlled Hoist Motors Showing the Action of the Limit Switches.

The trap gates for filling the bucket, allowing only a certain amount of coal to enter the bucket, are as in previously described equipments, and the dumping arrangement is the same. The cycle of operations beginning with bucket in the midway position is as described below.

The control handle which may be thought of as moving the contact fingers, shown in the controller diagram is first moved into the down position to the first step. This cuts all the resistance into the rotor circuit and the subsequent positions of the controller cut out resistance until full speed is reached in the seventh position. This starter controls an alternating current 25 hp. slipring motor, which is connected to the hoisting drum to which the bucket cables are attached. When the bucket has been lowered into the receiving pit, the automatic mechanically operated gates open and allow the bucket to be filled with coal.

To prevent over travel of the bucket through negligence of the operator, the down hatch way limit switch, shown in the lower right hand corner of the diagram, Fig. 27, is automatically opened. The bucket hits the roller "X," causes the switch to rotate about its axis "o," breaking the contacts at the points A. This de-energizes the solenoid "SO," of the gravity switch, allowing the armature to turn about its axis "p" breaking the main circuit at the point "OX," and applies the solenoid brakes. This prevents further travel in the down position, but permits the operator to raise the bucket, for when the controller is moved into the number one position on the up side, the gravity switch "MS" is again energized, again establishing the main circuit and the motor can be started. As soon as the bucket starts to raise, the down hatch way limit switch is closed by a spring and again completes the control circuit for the down position.

The up hatch way limit switch operates in the same manner to prevent over travel in the up direction, either of these limit switches can be shunted out if necessary by the small knife switch "S," shown below. This allows further movement after the limit switch has operated. Both these limit switches are placed at the top of the chute, the bucket operating one and the counterweight the other.

The resistance units are shown separated from the main diagram, but the different portions of this resistance are electrically connected to like numbered contact fingers on the controller, the connecting wires being eliminated for the sake of simplicity.

Capacity.

A chute equipped with this apparatus, working at its full capacity, is capable of hoisting from 40 to 50 tons of coal per hour, but it seldom happens that it is possible to utilize its full capacity as the operator and his helper generally spend part of their time unloading and breaking up the lumps of coal. When the receiving pit is full, they operate the hoist until this coal has been stored.

Automatic Electrically Operated Hoist.

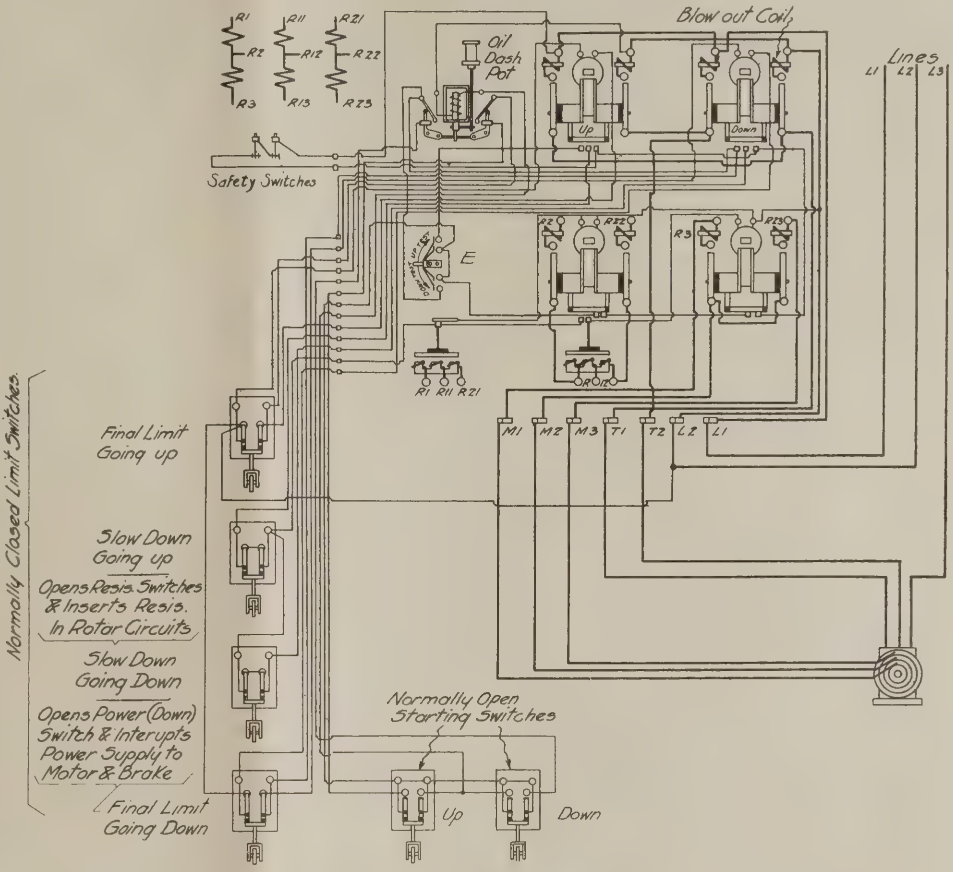
Method No. 5.—This hoist is entirely automatic in its operation and the automatic features are entirely electrical as will be shown. To start this hoist it is only necessary to close the main line switch at L1, L2, and L3, shown in Figure 28, and the control apparatus raises and lowers the bucket, automatically taking care of its acceleration. An alternating current 3-phase 25 h. p. slipring motor mechanically connected to the operating drum furnishes the driving power.

When either the bucket or the counterweight is on the landing timbers in the pit, one of the normally open starting switches shown at the bottom of Fig. 27 is closed, due to pressure on the fibre contact wheel. If the bucket were down the up switch would be closed, which would automatically cause the bucket to rise after it had been filled with coal. If the bucket had been stopped in a mid-position it would have to be started by means of the emergency starting switch shown at E, on the diagram which is wired in parallel with the starting switches shown at the bottom. If this fails to start the motor, the magnetic reversing switch "X" should be moved up as far as it will go after the service switch has been closed, providing fuses and contacts are all right.

When the starting switch is closed the coil "X," of the reversing switch in the upper left hand corner is energized, this operates against the oil dash pot "A" so that the necessary time element is introduced to allow the bucket to be filled with coal. When the dash pot plunger has been moved to the end of its travel by the solenoid, contact is made at the points B which starts the operation of the automatic cutout switches R2, or R3, depending on whether the bucket is going up or down. To prevent too rapid acceleration, current limiting solenoids "C" prevent more resistance from being cut out of the rotor circuit until the starting current has been reduced enough to allow the spring which backs the magnetic pull, to close the switch, making contact at point M, which connects in the next cutout switch.

Limiting and Reversing Switches.

When the bucket has reached a point 5 ft. from the top of its travel it trips a slow down switch which cuts resistance into the rotor circuit. The operation of these limit switches is exactly similar to those described in the previous method, mainly the bucket in passing the switch bears down on the small fibre wheel, breaks the contact at the points A. When the bucket reaches the top of its travel, the final limit switch stops it by breaking the main circuit and automatically applying the solenoid brakes. At the same time the normally-open starting switch, which starts the bucket in the down direction, is closed. Here the action of the solenoid "X" against the oil dash pot A again permits sufficient time to elapse for the bucket to empty before starting down.



Wiring Diagram of an Automatic Hoist. The Limit Switches Are Shown at the Left.

The points on the numbered resistance elements are connected to similar points on the magnetic cutout switches. Safety switches are generally applied within easy reach of the operators; these are simply single knife blade switches connected in series; pulling any one of these de-energizes the gravity switches SO and stops the motors.

Whenever the power is cut off from the motors, solenoid brakes held open by the power current are automatically applied.

After the motor is once started, the apparatus will automatically load and unload coal until it has been stopped either by a failure of the power supply or by the operator.

The oil or air dash pot is adjusted so as to allow the proper amount of time for the bucket to be filled and dumped. If care is taken to keep all the small contacts clean, this equipment will give very good service with very little attention.

The equipment used in these last two described methods is manufactured by the Cutler-Hammer Mfg. Company of Milwaukee.

Comparative Cost of Operation.

It is hard to accurately compare the operating cost of coal hoists in different localities even if the types are used. The costs given below are taken from a general average of several hoists of the same type and all assume the cost of electricity to be 2c per K. W. Hr. The costs are given for the different methods which have just been described.

Method No.	Required Watt Hours Per Ton	Cost of Current Per Ton @ 2c Per K. W. Hour
No. 1	508	.01016c
No. 2	488	.00976c
No 3.	130.7	.002615c
No. 4	136.5	.00273c
No. 5	221	.00442c

The costs do not vary greatly in these different methods, although particular attention is called to the difference between methods No. 3 and No. 4, in the former the hoist was driven by a 10 h. p. motor, while the chute is in operation, and the latter used a 25 h. p. run only when coal is being hoisted.

Mr. William A. Del Mar, who has for a long time been active on the Committee on Wire Specifications, has resigned from the electrical engineering department of the New York Central & Hudson River Railroad and will become assistant electrical engineer of the Interborough Rapid Transit Company of New York.

The Principles of Alternating Currents

Williard Doud

(Seventh Article.)

Wattless current as has been brought out in last lesson is the current exisitng in an alternating current circuit which does not perform any useful work and it is of such importance in the treatment of problems relating to alternating currents, it might be well to explain in further detail, the characteristics and effects on the current flowing in a circuit.

Power factor or the ratio of the apparent power delivered to a circuit, found by multiplying the ammeter and voltmeter readings together, to the true power, which is indicated by the wattmeter, must be clearly understood as it is practically always used in the calculations of alternating currents. The apparent watts is sometimes referred to as volt amperes or Kilovolt-amperes and the true watts or power is equal to the apparent watts multiplied by the power factor.

If the voltmeter indicates 200 volts and the ammeter 100 amperes the apparent power will be $200 \times 100 = 20{,}000$ volt amperes or 20-Kilo-volt amperes. If a power factor of the load is 80 per cent due to an inductive load of arc lamps, induction motors and transformers, being operated, the true power will be $200 \times 100 \times .80 = 16{,}000$ watts or 16 kilowatts. The difference between the 20,000 apparent watts and the 16,000 true watts or 20 per cent is wattless current.

In a circuit whose power factor is 1 or unity, the current is in phase with the voltage and delivers true energy. If the power factor is zero all of the current flowing is wattless. Any degree of power factor between 0 and 100 shows the exact relation of the true energy in a line to the apparent energy indicated by the voltmeter and ammeter. A wattless current is always displaced 90 degrees from the working or true current. As has previously been explained, this being the case, combining the wattless and true current at 90 degrees by the method of vector summation or parallelogram of forces explained in the April issue of the Railway Electrical Engineer, the resultant or total current is obtained.

An analogy, which is commonly used and which, perhaps, illustrates quite clearly the meaning of wattless current and power factor, is that of a canal boat towed by a short piece of rope from the bank, the rope making an angle with the direction of the boat's motion.

The following diagrams will illustrate the principle features of the canal boat analogy.

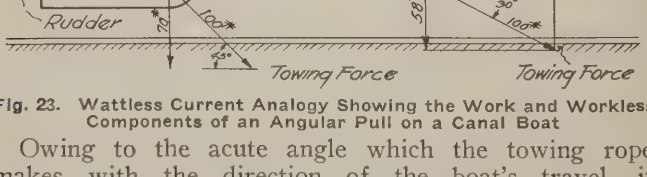


Fig. 23. Wattless Current Analogy Showing the Work and Workless Components of an Angular Pull on a Canal Boat

Owing to the acute angle which the towing rope makes with the direction of the boat's travel, it is evident that all of the pull on the rope will not be effective in pulling the boat forward as a portion will tend to move the boat toward the shore and must be balanced by the rudder.

The pull on the towing rope may be divided into two parts; one in the direction of the boat's travel, which is the effective (true) pull and the other at right angles or 90 degrees to the boat's direction which is the workless (wattless) pull.

If the angle of pull is 45 legrees and the pull on the rope is 100 pounds, then there is a pull of 70 pounds forward and 70 pounds towards the bank.

Similarly if the angle of pull is 30 degrees there will be a forward pull of 87 pounds and a pull of 58 pounds towards the bank.

If the angle is zero the effective or forward pull will be equal to the total pulling force, while with an angle of 90 degrees the effective or forward pull will be zero and the boat will not move in the desired direction.

The effective (true) pull is always equal to the total pull times the cosine of the angle which the towing rope makes with the direction of the boat's travel.

If there are several towing ropes pulling at different angles and with different degrees of force, the total effective pull and the total workless pull for each rope may be obtained by adding the sums of the effective pulls together and the sums of the workless pulls together. The ratio of effective pull and the total pull may be considered as the power factor, the apparent power as the speed of the boat times the total pull, while the true power or effective pull will be equal to the speed times the total pull multiplied by the power factor.

To make the boat analogy applicable to alternating currents, the voltage may be considered as the boat's direction and the current to the pull on the towing rope. When the current (pull) and voltage (direction) are in the same direction (in phase) the effective (true) current equals the total current. If the current is at right angles to the voltage, the effective (true) current will equal zero. If the current is displaced 30 degrees from the voltage, the effective current equals the total current multiplied by .87, the power factor.

In any alternating current circuit, the total current and watts being known it is a simple matter to find the effective (true) and wattless (workless) portions or components of the current. If one machine is in the circuit divide the reading of the wattmeter in watts (true power) by the reading of the voltmeter in volts times the reading of the ammeter in amperes (apparent) power and the result will be the power factor, that is the percentage of the apparent power which is available for doing work.

If there is more than one machine in the circuit, taking different amounts of power, the total effective and total wattless currents may be obtained by taking the sum of all the effective currents and all of the wattless currents and dividing these quantities the result being the power factor of the circuit.

The setting of the boat rudder in Fig A at an angle with the direction of travel of the boat indicated by the arrow, adds resistance to the travel of the boat and this loss of energy may be likened to the loss in an electric circuit due to the flow of wattless current.

Circuits of low power factor require current-carrying capacity equal to that needed for transmission or energy without wattless current, some means must be available for increasing the power factor of circuits which are so effected.

Arc lamps, induction motors and transformers have a low power factor, due to the magnetizing current required in the current carrying coils used in their construction. When transformers and motors are operated at loads much below their normal rated capacity the wattless current in the circuit is much greater in proportion to the total current flowing than when they are fully loaded. Thus one means of improving power factor is the selection of motors and transformers which will operate as near normal rating as possible. Another method of improving power factor is to supply to the circuit current in which the current leads the voltage by a certain angle.

Any alternating electrical circuit may be given a power factor of 1 or unity by adding a leading current which is equal to the lagging current. If the leading current added is not equal to the lagging current the total current will still lag but to a less degree than if no leading current had been introduced.

The synchronous motor is the usual instrument for delivering leading current to a circuit of low power factor and the canal boat analogy will again be used to explain its method of action.

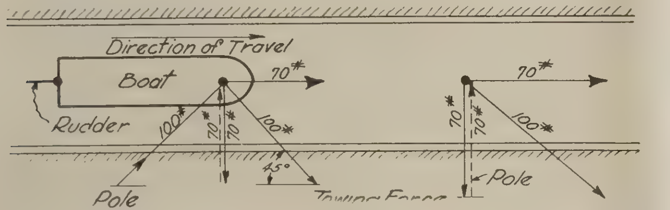


Fig. 24. Wattless Current Analyogy Showing How two Workless Components can Neutralize Each Other Like a Combination of Inductance in Capacity

Assuming the boat to be traveling in the direction indicated by the arrow, propelled by a rope making an angle of 45 degrees with the boat's direction and also pushed by a pole which has the same angle as the towing force with the boat's direction.

With the pull on the towing rope and the force at the end of the pushing pole assumed as 100 pounds each, the rope will give a forward pull to the boat of 70 pounds and a pull toward the bank of 70 pounds. The pole will give a forward push on the boat of 70 pounds and a push away from the bank of 70 pounds. Thus the total effective power available to force the boat forward in its direction of travel is 70+70 or 140 pounds and there is no tendency for the boat to move toward or away from the bank since the pull toward the bank is exactly balanced by the pushing force away from the bank. This being the case the rudder may be set in line with the direction of the boat's travel and consequently will offer no resistance to the motion of the boat.

Again assuming the pull on the towing rope is 100 pounds at 45 degrees and the push on the pole is 70 pounds the force and the pole will balance the 70 pound force toward the bank and the effective power available for moving the boat forward will be equal to but 70 pounds. If there are a number of ropes pulling at different angles it is always possible to find the total pull toward the bank and balance this force with an equal push.

The towing rope may be compared with an induction motor taking a current of 100 amperes which lags 45 degrees behind the voltage and the pushing pole to a synchronous motor taking current of 100 amperes which leads the voltage by 45 degrees. The induction motor current may be divided into two portions or components, one of 70 amperes in phase with the voltage and one of 70 amperes at right angles to and lagging behind the voltage. The synchronous motor current may be divided into two components, one of 70 amperes in phase with the voltage and the other of 70 amperes at 90 degrees to and leading the voltage. As a consequence, the 70 ampere leading current counter balances or cancels the lagging current of 70 amperes and the total current in the circuit used by the two motors is 140 amperes, the current being in phase with the voltage, the true power delivered being equal to 140 times the voltage, neglecting the power consumed in the resistance.

The Railroad Electricians' Club

New York Electric Car Lighting Association

Meetings of the New York Car Lighting Association have been continued during the summer months because of the fact that the association was started in May.

The October meeting of the club will be a special meeting, known as the Annual Meeting, and will be made a general get-together time for all car lighting men in New York. This will be held on the first Tuesday of October in one of the large offices of the New York Central Terminal.

The Lead Storage Battery.

At the September meeting of the club the subject of the lead storage battery was discussed and a committee, of which Mr. G. Wall, of the Lackawanna, is chairman, presented a report on the subject. This report covered a historical review of the development of the storage battery and also described the various types of batteries in considerable detail.

Mr. Edward Wray, of the RAILWAY ELECTRICAL ENGINEER, attended the meeting and was called upon for a few remarks. He complimented the committee upon the completeness of their report and added a few of his own thoughts on the storage battery question.

Mr. Wray stated that the practical man on the job very often desired to get some idea as to what goes on when a storage battery charges or discharges.

He called attention to the fact that there are various kinds of energy; potential energy, such as the dormant energy of coal, the energy of a suspended weight ready to drop or the energy of a revolving fly wheel; and on the other hand, kinetic energy or energy at work, and this may be either mechanical or electrical.

It is an interesting fact that it is possible to transform energy from one type into another. By means of the boiler and steam engine we can transform the chemical energy of the carbon in coal into mechanical energy; by means of the dynamo, we can transform the mechanical energy of the steam engine into electrical energy and by charging a storage battery we can transform electric energy into chemical energy—for this is just what takes place when a storage battery is charged. The chemical condition of the active elements of the battery is changed and the degree of this chemical change represents the amount of charge given the battery. There is no mysterious storing up of electricity itself in charging a storage battery.

The storage battery, however, has the peculiar property that the chemical energy given it on charge is easily transformed again to electrical energy by simply closing the circuit, but here again, as the current flows through the battery in a discharge direction, another chemical change, the reverse of that on charge, takes place.

Mr. Wray pointed out that in a lead battery the electrolyte plays an important part in the chemical change which goes on either in charging or discharging. On discharge the sulphuric acid of the electrolyte enters both negative and positive plates, combining with the active material, and the greater the amount of discharge, the greater will be the amount of acid held in chemical combination within the plates.

In a fully charged battery the two plates are different, the positive being of lead peroxide (PbO_2) and the negative sponge lead or (Pb); but in a fully discharged battery, one giving no potential whatever, the two plates would be identical, both PbO. This, however, having combined with the acid of the electrolyte, which enters the plates on discharge, will be in the form of soluble lead sulphate. Allowing the plates to stand in this discharged condition this will change from the acid or soluble sulphate to the white or insoluble sulphate, which ruins the plates.

On discharge the electric current which is forced through the battery not only causes the positive plate to be oxidized to lead peroxide (PbO_2) and the negative plates to be reduced to sponge lead (Pb), but this charging current also breaks up the chemical combination of the acid with the (PbO) or dead active material in both plates.

There is then an actual flow of acid into the plates on discharge and out again on charge. This acid must diffuse through the pores of the active material of the plates and as these pores are extremely fine, the action takes place rather slowly, particularly when the active material which is being worked, lies deep down in the plate so that the acid must diffuse through a thick wall of active material. This causes the action to go on more slowly at the finish of either charge or discharge, and it is largely due to this one fact that a higher voltage is required in order to force this chemical change to go on at the same rate at the end of charge (constant charging current), and in the case of discharge, it causes the discharge voltage to gradually decrease until near the end of charge it falls quite rapidly.

It is just as important to understand the mechanical action which goes on inside a storage battery as it is to understand the electrical or the chemical action, for having a clear understanding as to how the acid goes in and out of the plates will help us in explaining to ourselves some of the things which occur in the operation of a storage battery.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 44

Gould Lamp Regulator--Cont'd

Generator Regulator Panel.

The adjustments of the potential and current coils of the generator regulator are made at the factory and no further adjustment in service should be necessary. In case it does become necessary to alter the setting of either of these coils, this must be done by adding or removing weights from the dash pot plunger of that coil; adding weights will increase the voltage setting and removing weights will decrease it by 1 volt per weight approximately on 30-volt system, and 2 volts per weight approximately on 60-volt system.

Removing the Regulator Coil.

Both the current and potential coils of the regulator are constructed exactly the same, except so far as the size of wire used in winding is concerned. In case it becomes necessary to remove either one of these coils, the complete coil and frame should be removed entirely from the board. This is done by first removing the dash pot, then the pin at the top of the plunger, connecting the links to the lever. Be sure to hold the plunger to prevent it from falling; screws connecting the terminals to the connection blocks should be removed. The two screws holding the magnet frame at the top should then be removed and the two screws holding the frame at the bottom loosened. These screws are located back of the dash pot and as they are difficult to get at, the feet of the magnet frame are slotted so that once the screws are loosened the frame may be lifted off the board.

Then remove the piston and plunger of the coil from the magnet frame and unscrew the three screws holding the dash pot cover to the bottom of the magnet frame; this cover carries the guide rollers for the plunger and also the brass retaining tube of the coil. This retainer is a brass tube soldered to the dash pot cover and is slipped up through the center of the coil, holding it firmly in place. In case the tube sticks in the coil so that it is difficult to remove it, insert a screw driver in a slot at the bottom of the magnet frame for this purpose. With the retainer tube removed, the coil at once falls out of the magnet frame. In replacing a coil the operation is just the reverse.

Automatic Switch.

The automatic switch can easily be adjusted so as to close at the proper voltage. After the train has gotten up good speed and the automatic switch normally closed, raise the field resistance arm on the voltage side of the regulator. This will loosen the carbon pile and cause the generator voltage to be reduced until the automatic switch drops open in the usual manner. Then, with a voltmeter cross the generator terminals, gradually lower the field resistance arm. This will gradually raise the generator voltage and this voltage should be noted by watching the voltmeter as the automatic switch closes.

If the switch closes at too low a voltage, loosen the set screw at the top face of the magnet frame and back up on the pole screw at the top of the frame by inserting a pin in holes provided in the periphery of the screw for this purpose. This will raise the upper pole of the switch so as to increase the air gap and require a higher voltage across the lifting coil of the switch in order to lift the plunger and close the switch.

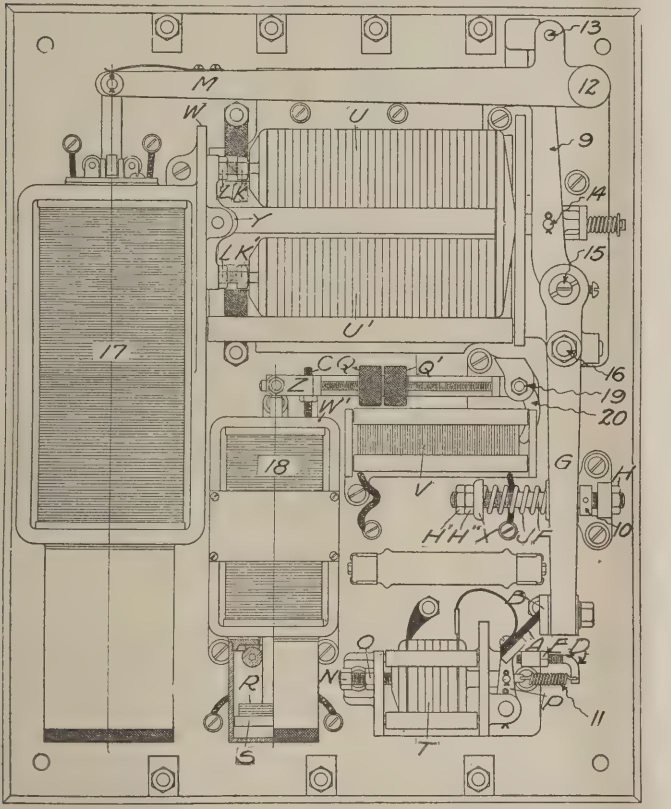


Fig. 220. Gould Type "M" Lamp Regulator

Then try the switch as before, and note the voltage at which it closes. If the generator voltage goes too high before the switch closes, run in the pole screw at the top of the magnet frame and this will lower the upper pole of the switch, closing the air gap and allowing a lower voltage across the lifting coil to lift the plunger and close the switch. The proper adjustment of this pole screw can easily be determined by trial.

Renewing Auto Switch Parts.

The brushes and carbon contacts of the auto switch are, of course, occasionally renewed. A new brush can be added by simply unscrewing the screws holding the old brush, and inserting a new one in its place. Brushes are slotted so that they can be adjusted to proper position so that the contact block on the plunger makes contact with both brushes at the same time. The brushes should be set so that they do not close contact until after the carbons, but should make solid contact when the switch is closed and the two plungers of the auto switch come together. The plunger of the switch carries a piece of brass at the upper end so that it will not stick to the upper pole.

The carbons should be set so as to close just before the copper contacts. It will be noted that they are each carried on an L-shaped arm which pivots on the contact block and the lower projections of the two arms carry a spring between them, which forces the carbons to make firm contact, yet does not retard closing of the switch. With switch open the metal to metal break should measure ⅛ inch and the carbon to carbon break 1/16 inch.

In order to renew either one of the coils of the automatic switch, remove the whole switch from the board by removing the two screws at the top and the two at the bottom and disconnecting the leads of both the series and voltage lifting coils; unscrew the two guide posts at the bottom and remove the plunger of the switch, then unscrew and remove the upper pole complete with the retaining tube. The coils will then fall out and it will be noted that the voltage or lifting coil is wound inside of the heavy series coil. In replacing coils, the operation is just the reverse, but care should be taken to make sure that connections are made exactly as before.

Renewing Field Resistance Carbons.

Remove the cover of the pile and also the rod holding the glass tube at the top of the pile. By raising one of the levers, carbons can then be picked right out as desired and new carbons added. Enough carbons should be added until one of the levers is just held off its roller guide.

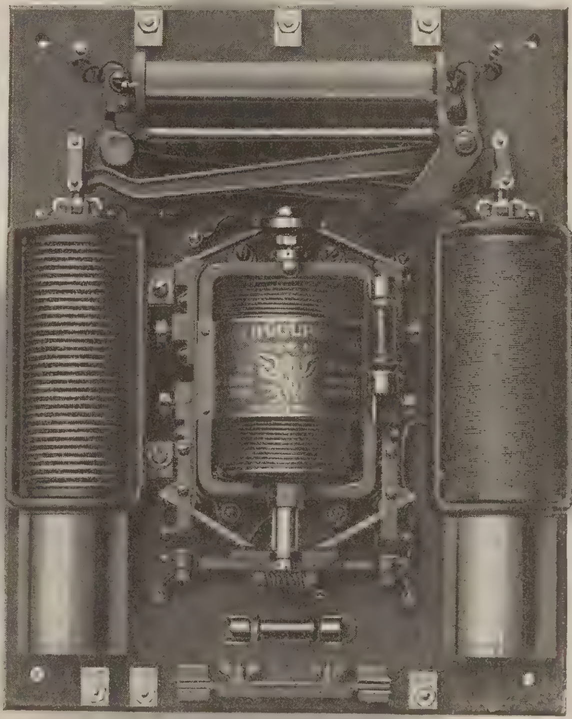


Fig. 210. Gould Simplex Generator Regulator Panel. The Series Regulating Coil Shown at the Left and the Voltage Regulating Coil, Shown at the Right, the Carbon Pile at the Top and Automatic Switch in the Center

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Handy Arc Welding Resistance.

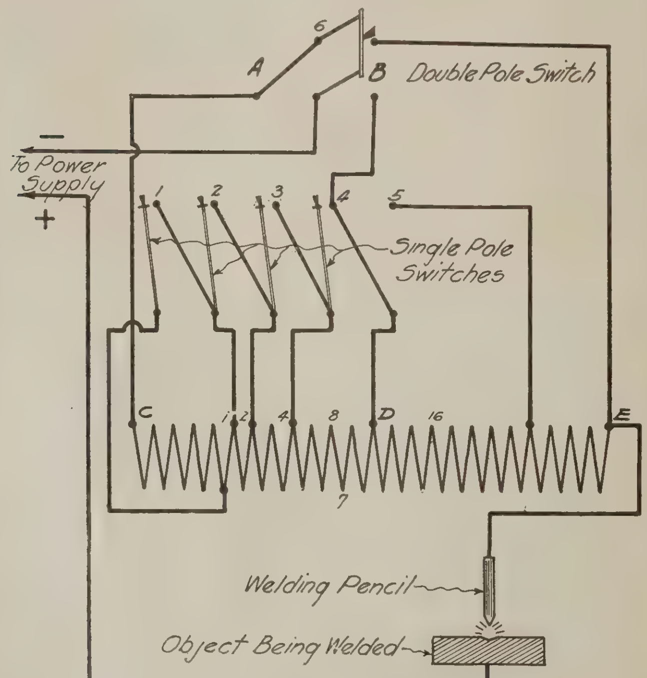
Here is an arc welding resistance which we have found to be most useful. We have been using it for some time and with it a welder has no use for an ammeter, since he knows the current that will flow with different combinations of switches and he is always operating with a closed circuit.

Below is given a sketch of the wiring diagram of the resistance circuit for electric welding.

The accompanying sketch is a wiring diagram of an electric welder circuit, which we have found to be very useful and convenient to operate.

Nos. 1, 2, 3, 4, and 5 are single pole, single-throw knife switches.

No. 7 is a bank of resistance composed of 48 parts or girds.



Arrangement of Resistance Connections for Varying the Resistance of an Arc Welding Circuit

Switch No. 1 short circuits 1 part or 1/48th of total resistance.

Switch No. 2 short circuits 2 parts or 2/48ths of total resistance.

Switch No. 3 short circuits 4 parts or 4/48ths of total resistance.

Switch No. 4 short circuits 8 parts or 8/48ths of total resistance.

Switch No. 5 short circuits 16 parts or 16/48ths of total resistance.

Switch No. 6 is a double pole, double throw, and when in position A all resistance is in series and when in position B the resistance divided in the center and each half placed in parallel.

For pencil welding place switch No. 6 in position A and have switches Nos. 1, 2, 3, 4, and 5 open, which will give you the smallest amount of current, for all resistance is in series. By opening and closing switches Nos. 1, 2, 3, 4, and 5 you can gradually increase your current and get 32 different regulations from lowest to highest.

By closing switch No. 1 you cut out 1/48th of resistance. By opening No. 1 and closing No. 2 you cut out 2/48ths of resistance.

The following combinations will change the resistance as shown at the right:

Switches Closed	Portion of Resistance Cut Out.
1 and 2	3/48
3	4/48
1 and 3	5/48
2 and 3	6/48
1, 2 and 3	7/48
4	8/48
1 and 4	9/48
2 and 4	10/48
1, 2 and 4	11/48
3 and 4	12/48
1, 3 and 4	13/48
2, 3 and 4	14/48
1, 2, 3 and 4	15/48
5	16/48

The largest mount of current is obtained by closing switches Nos. 1, 2, 3, 4, and 5, which cuts out 31/48ths of the total resistance, which will give you the largest current with resistance in series. For carbon welding place switch in position B and have switches Nos. 1, 2, 3, 4, and 5 open.

By operating switches Nos. 1, 2, 3, 4, and 5 as described above, you get 32 more, making 64 different currents from lowest to highest.

E. L. Work,
Columbus, Ohio.

Effect of Oil on Brushes.

To the Editor:

I would like to ask some of the axle light fraternity if they ever have trouble with generator brushes absorbing oil, making it almost impossible to keep commutator clean.

Of course, a machine that is carefully oiled should not shed oil on the commutator, but the fact is that some terminal inspectors will persist in flooding machines. Now, as carbon is very porous, a large quantity of oil is absorbed and as soon as the brush becomes warm the oil comes right out, with anything but beneficial results. We have tried several schemes for getting rid of the oil and so far gasoline seems to give the best results, although it is not altogether satisfactory for the reason that when gasoline comes in contact with oil, the latter recedes and a large portion of it goes deeper in the brush, although the outside may be very clean. The result is a dirty commutator as soon as the brush gets warm.

Some one suggested to me to impregnate the brushes with parffine in order to stop up the pores and prevent absorption. This, however, was immediately abandoned on account of the paraffine coming out and coating the commutator. In this case the cure was worse than the illness. Hoping to hear from some of the boys, I am, E. C. Meilloret, L. I. R. R. Shops, New York.

"Dan Patch" Gas Electric Locomotives

The Minneapolis, St. Paul, Rochester & Dubuque Electric Traction Co., operating what is popularly known as the "Dan Patch" Electric Lines, has recently placed in commission three 60-ton gas-electric locomotives for freight, passenger and terminal service. These are somewhat similar in design although heavier than the 57-ton gas-electric locomotive which has been in successful operation daily on the company's lines for the past year or more from Minneapolis to Mankato, Minn. The four gas-electric locomotives, as well as thirteen gas-electric motor cars which the railway company has purchased to date, were designed and built by the General Electric Company. It is interesting to note that this is said to be the first railroad in the world operated entirely with gas-electric service.

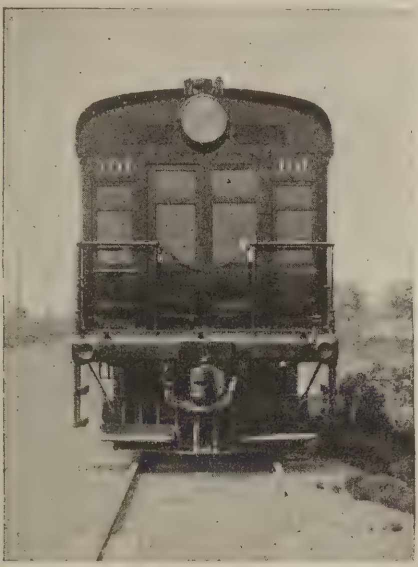


Fig. 1. End View 60-Ton Gas-Electric Locomotive for "Dan Patch" Electric Lines.

The railway extends south from the company's terminal building in Seventh Street, Minneapolis, a distance of 107 miles to Mankato. About midway of the line a branch runs northeast from Northfield to Randolph, 7 miles distant. Another extension is contemplated from Faribault southeast to Owatonna, Waseca, Geneva, Albert Lea, Austin, Dodge Center, Rochester and beyond, having Dubuque, Ia., as its objective terminal point. The fine rolling section of Minnesota thus traversed, with productive grain fields, dairy and truck farms, and numerous thriving towns and cities of varied industrial activity, is one of the most prosperous in the state.

The territory presents few difficulties in road construction, the severest grade on the present line being 2 percent. The roadway was built, and improvements are being constructed, with a view to permanent stability, reinforced concrete being frequently used in the work. Substantial stations, similar to those used by steam railroads, are located at the various cities and towns along the route; and smaller stations have been erected every few miles at rural stops to afford protection to the traveling public from inclement weather.

About 25 miles south of Minneapolis, at Orchard Gardens station, several thousand acres of farm land have been divided into 5 and 10-acre tracts by the company and are being sold to residents of Minneapolis and St. Paul, many of whom have erected houses and travel to and from their places of business in the city each day on the railway. There are also many attractive lakes along the route, affording excellent facilities for boating, bathing and fishing, which lures thousands of city dwellers out into the open country and to cottages during the summer months. Antlers Park, a summer resort and recreation park 30 miles south of Minneapolis, is owned and operated by the traction company.

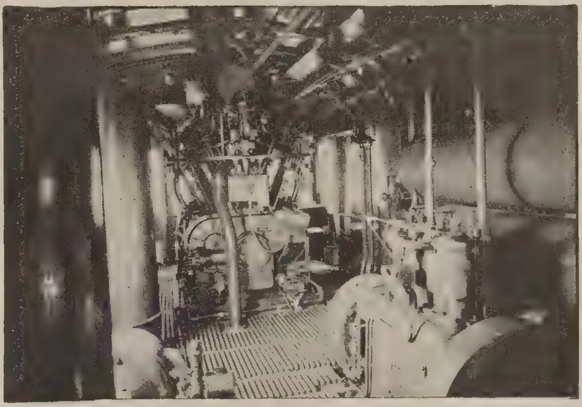


Fig. 2. Interior of Cab of 60-Ton Gas-Electric Locomotive for "Dan Patch" Electric Lines.

Train Schedule.

Four through trains daily each way, one of which is a limited parlor car train, constitute the normal passenger schedule of the road. The limited makes the run of 107 miles, including four stops, in 3 hr. and 25 min.; while the other trains require 4 hr. and 5 min. for the trip. This service is supplemented by local trains between certain points of the line and the terminals, and by excursion trains during the summer season as occasion requires. One 70-ft. gas-electric motor car, seating 89 passengers, normally makes the run; when travel is somewhat heavy, a trailer is added to this; and for excursions and extra heavy traffic, a train is made up of trail cars drawn by a 60-ton gas-electric locomotive.

Locomotive Details.

The new 60-ton locomotives are double ended and are designated type 404-G-120-4-GE-205-D. They are built with the box type of cab extending nearly the entire length of the underframe and have all the weight on drivers. Each locomotive is equipped with four GE-205-D motors. The truck clearances allow for 100 ft. minimum radius curvature. The power plant consists of two generating sets similar to the one used in the gas-electric motor cars. Only an engineer is required to operate the locomotive.

The box cab is of all-steel construction. The side posts and rafters consist of "T" iron and angles covered with sheet steel plates having lap and butt joints securely riveted. Outside platforms of suitable width, protected by hand or guard rails and mounted by iron sill steps, are left at each end to provide entrance through the end center doors. Both ends of the cab are also removable to permit readily the installation of the apparatus. The interior is not divided into compartments. The generating sets and the controllers are installed in each end, while the auxiliary lighting set, air compressor and storage tanks are grouped in the central section. The operator's seat at the side of each end of the cab affords a clear view ahead of both sides of the track. There is also an engineer's sliding side window, which is fitted with an arm rest and assists in giving ventilation, as well as an ample view both of the track and signals. All other windows drop into pockets and are arranged for adjustment. There are fourteen in all, including those in the doors, affording plenty of light in the cab.

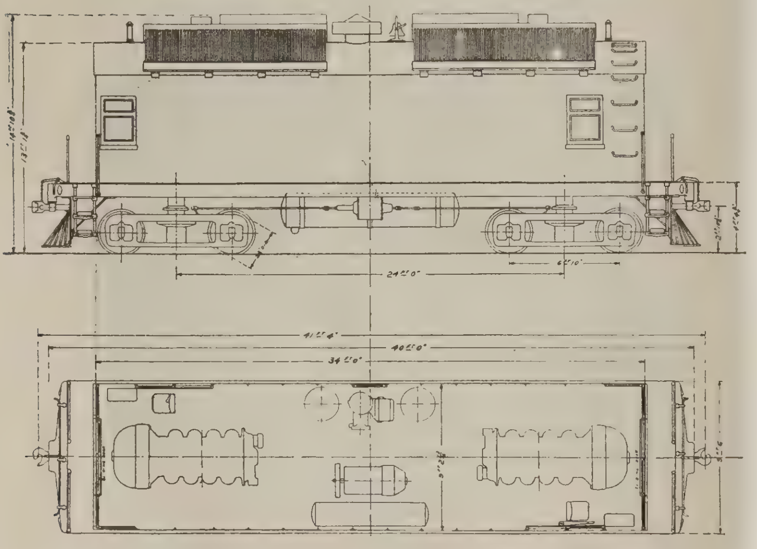


Fig. 3. Dimension Outline of 60-Ton Gas-Electric Locomotive for "Dan Patch" Electric Lines.

The underframe of the locomotive consists of two 10-in. 30-lb. section, longitudinal channels both for the outside and center sills. These extend the entire length of the platform, and are tied together by heavy end frame cast steel buffers and bolster plates, each channel being riveted to the webs of the end frame castings and bolted to the top and bottom bolster plates. The bolsters are built up of 12-in. by 1⅛-in. steel plates, the top bolster being carried clear across the platform and riveted to all four longitudinal sills. The cast steel center plate castings are bolted to the bolster plates. Cross sills are riveted in where it is necesary to support equipment hung below the frame.

The drawhead castings are attached to the center sills. The draft gearing consists of standard MCB top operated tender couplers with 5-in. by 5-in. shank, yoke, twin springs and follower plates. The entire platform is floored and braced by ⅜-in. steel plates running the width of the locomotive and riveted to the longitudinal sills. In the cab this is covered with wooden slatted matting. Pilots of steel angles with running board are bolted to the end frames and braced back to the side sills with bar iron.

The two four-wheel swivel trucks are of the plate frame swing bolster type, designed for heavy freight work and conform to MCB standards. The side frames are built up of steel boiler plate with cast iron pedestals, which are bolted to the frames and securely fastened together at the bottom by steel caps bolted on. The transoms are built up of steel channels, rigidly braced and bolted to the frames with cast steel gussets. The truck bolster, of the swinging type, is built up of channels and pressed steel, and is supported on heavy triple semi-elleptic springs, Potter ends, hung by adjustable wrought iron swing links to the double side equalizer bars, which in turn rest on the journal boxes. The coil equalizer springs are cast steel tempered in oil.

The journal boxes, fitted with bronze babbitted bearings and wedges, conform to MCB standards. The wheels are solid rolled steel, 33 in. dia., with MCB treads and flanges, 1913 contour. The axles are forged open hearth steel, 6½-in. dia. between the wheels and with 5½-in. by 10-in. journals. The air brakes, with 16-in. brake cylinders, are the combined straight and automatic type, AVMS schedule, arranged double end control. The brake shoes are cast iron inside hung, the heads being supported by hangers. The brake levers and connections are arrayed for easy slack adjustment. Air is supplied from the main engine compressors piped to the air tanks. The connections between the tanks and to the operating valves are arranged to furnish air for starting and for operation of the brakes from independent sources. The brake rigging is proportioned for a brake shoe pressure of 85 per cent of the weight on the drivers with 50-lb. pressure in the brake cylinders. A hand brake with staff and handle is also provided and connected to act in conjunction with the power brakes.

Electrical Equipment.

Taking up the electrical equipment, each of the two gas-electric generating sets for the power plant equipment is composed of a 175 h-p., 550 r.p.m., 8-cylinder, 4-cycle gasoline engine of the "V" type, which is direct-connected to a 600-volt, commutating pole, compound wound electric generator with an outboard bearing supported by brackets bolted to the magnet frame. The cylinders are 8 in. dia. bore by 10 in. stroke. Ignition is accomplished with low tension magnetos and the sets are started by air pressure the same way as in the gas-electric motor cars, with the additional feature that after one set is running, the second may be started from the first electrically. The control is so arranged that either one or both of the generating units may be used to operate the locomotive from either end, in accordance with the requirements of the trailing train load.

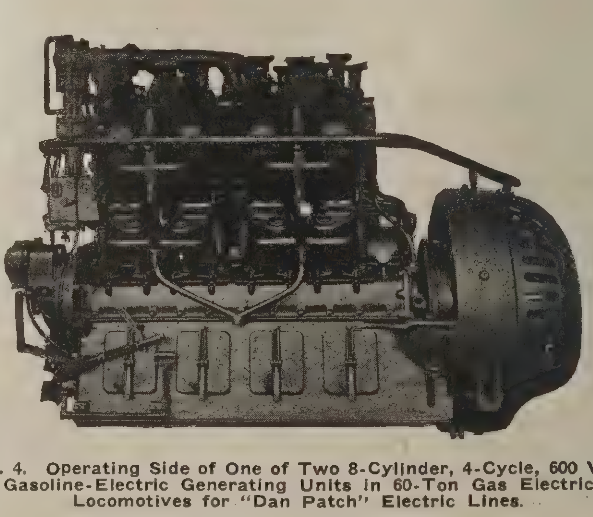


Fig. 4. Operating Side of One of Two 8-Cylinder, 4-Cycle, 600 Volt, Gasoline-Electric Generating Units in 60-Ton Gas Electric Locomotives for "Dan Patch" Electric Lines.

Compressed air for starting is taken from the main reservoirs of the air brake system, which are built with surplus capacity. The two main single-cylinder air compressors are driven from the crank shafts of the main engines, have a displacement of 22.5 cu. ft. of free air per min. at the rated speed and are fitted with automatic governors to maintain a constant pressure. Greater flexibility of control and economy of operation result through electrical transmission of the energy. The engines can rotate at normal speed irrespective of the speed of the locomotive and deliver their maximum power, a feature of great advantage on grades, in case of snow storms or other emergency conditions involving sudden, heavy current demands.

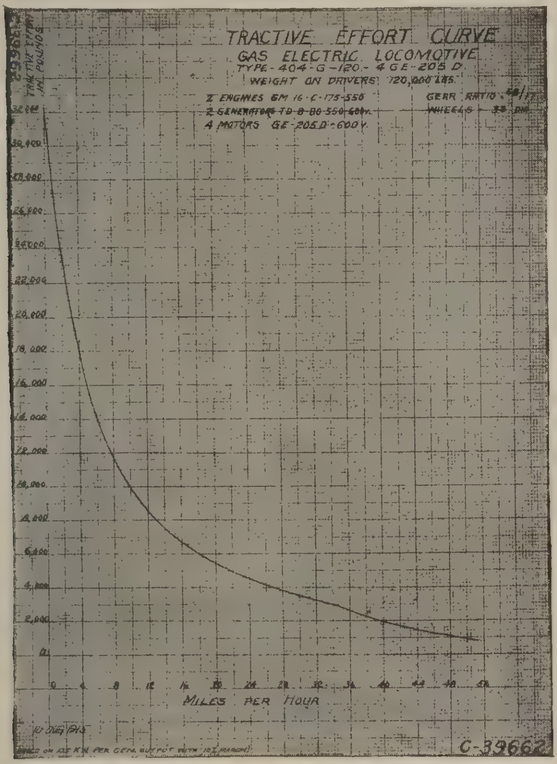


Fig. 5. Tractive Effort Curve Showing Approximate Performance of 60-Ton Gas-Electric Locomotives for "Dan Patch" Electric Lines.

The Gas Engines.

Throughout the engines are of the highest type of construction. The base is cast with suitable hand hole plates for inspection of the working parts, the crank case is cast iron and the bearings are babbitt lined. The cylinders are of cast iron and have removable heads. The crank shaft is of high carbon steel, oil treated, and the connecting rods are drop forged. The cam shaft is drop forged, with the cams integral, one on each side of the engine, the working surfaces of the cams being case-hardened and ground. The carburetor is the automatic, constant level, duplex type. Cooling water is circulated by a rotary pump, the water jackets being cast integral with the cylinders and heads. The gasoline pumps are the plunger type, the main pump being direct-driven from the engine; and the auxiliary pump, hand-operated for filling the carburetors when first starting. Positive lubrication is provided by oil under pressure. The pistons are of the trunk type and are fitted with cast iron piston rings. The piston pins are of hardened steel and ground.

Auxiliary Gas Electric Set.

There is also an auxiliary gas-electric set, the function of which is to furnish power for lighting the cab, headlights and train coaches, and for pumping an initial charge of air to fill the tanks and start the main engines. This set is started by hand. It consists of a vertical, 750 r.p.m., 4-cylinder, 4-cycle gasoline engine, which is direct-connected to a 5 kw., 65-volt, commutating pole, compound wound, electric generator. The cylinders are 3 in. dia. bore by 6 in. stroke, and ignition is effected by a high tension magneto. The air compressor on the 65-volt circuit is a two-cylinder, motor-driven, railway type CP-28, and has a piston displacement of 25 cu. ft. per min. when pumping against a tank pressure of 90 lb. per square inch. Air is taken from the cab interior through screens and is delivered to the three reservoirs, each 87½ in. by 18 in., installed at one side of the cab in the center and connected in series, thereby affording an opportunity for radiation of heat and condensation of moisture before entering the brake cylinders. After starting the main engines, the governor on this motor-driven set cuts it out and all air is supplied by the air compressors on the main engines.

Mounted on the axles with nose suspension are four 600-volt, series, commutating pole, oil-lubricated, box frame, railway motors having an hourly rating of 100-h. p. each. All four axles are therefore driving axles, a forged pinion being mounted on each armature shaft and meshing into a corresponding cast steel split gear mounted on the axle. The gear ratio is 58 by 17 teeth, a reduction of 3.41, which is especially adapted for freight and terminal switching service, as it affords maximum tractive effort at start and low speeds. The motors are ventilated by a special vacuum system in conjunction with the engines. The performance of the locomotive is shown approximately in the curve giving the tractive efforts obtainable at various speeds.

Speed Regulation.

The control of the motor equipments is similar to that of the standard gas-electric motor cars, a type P-53 controller being installed in each end. Two motors are, however, connected permanently in parallel and these two pairs, operated like single motors, are placed progressively in series and parallel. The controller provides seven running steps in series and six in parallel, without rheostats in the main circuit. There are also two additional points for shunting the series fields, making a total of fifteen efficient running points.

Inasmuch as electrical energy is transmitted directly, there are no losses through the intervention of mechanical change-speed gearing. To produce the smooth and rapid acceleration, the speed changes of the motors are effected by governing the voltage through varying the strength of the generator fields, which is accomplished by the movement of one handle on the controller. Separate handles are provided for throttling the engine and for reversing the motors. The latter is accomplished instantly by changing the motor connections in the usual manner, without stopping the engines, which always rotate in the same direction. This allows the train to be brought to a halt quickly independent of the brakes in an emergency.

The 300 gal. gasoline storage tank, fitted with filler and filter, is installed underneath the underframing, as is also the brake cylinder. The radiators are the fin tube type and are mounted on each end section of the cab roof. The cooling water is circulated by the thermo-syphon system. There is also a radiator draining system, the tanks being situated at one side in the central section of the cab. A suction type ventilator is mounted in the roof between the radiators. A roof ladder is provided on each side of the cab and all necessary grabs in accordance with I. C. C. requirements.

A single unit headlight, fitted with a 250 watt, 65 volt, gas-filled Mazda lamp, is mounted on each end of the cab. Double pneumatic sanders, a 40-pound composition bell with pneumatic ringer and cord, and a pneumatic whistle are operated from either end of the cab. The end sliding doors are of wood and are fitted with locks and handles. They have glass in the top panels and air registers below. Air registers are also inserted in the upper and lower panels of the cab ends. Car lighting arrangements include six Mazda ceiling lamps; four receptacles for the portable lamp; one portable lamp with guard, flexible cord and plug, and bus line connections at each end for train lighting. The usual complete equipment of tools is included.

Principal data and dimensions of locomotives:

Total net weight equipped on rail	120,000 lb.
Weight per axle	30,000 lb.
Maximum tractive effort	32,200 lb.
Length between knuckle faces of couplers	41 ft. 4 in.
Length over cab	34 ft.
Height over all	14 ft. 10¾ in.
Width over all	10 ft. 2 in.
Total wheel base	24 ft.
Rigid wheel base	6 ft. 10 in.
Track gauge	4 ft. 8½ in.

S. K. F. Ball Bearing Bulletin.

The S. K. F. Ball Bearing Company have prepared for the use of railway electricians a bulletin entitled "S. K. F. Ball Bearings for Car Lighting Generators." This well prepared and artistic bulletin discusses the design and assembly and describes the application of S. K. F. ball bearings to various types of car lighting equipment.

The first section gives detailed information concerning the S. K. F. bearings, such as strength, quality, design, etc., another section tells how plain bearing generators can be changed over for use with S. K. Fs., and the rest of the pamphlet contains illustrations showing some of the adverse conditions under which bearings must work in this class of service.

Series Mercury Arc Rectifier Outfit.

The General Electric Company has just issued Bulletin No. 43900, describing that company's Combined Unit Series Mercury Arc Rectifier Outfits. This outfit is designed to convert alternating current into direct current for the operation of Series Luminous Arc Lamps. The various devices composing the outfit are so arranged as to require a minimum amount of space, simplified connections and afford the greatest safety to the attendant. These sets are made in 25, 50 and 75 light sizes, for 25 and 60 cycles, 2,200 volt primary, and 4, 5 and 6.6 amp. secondaries. The construction of the outfit is illustrated and described in considerable detail. The bulletin contains dimension and connection diagrams, together with catalogue numbers and other data.

Our Argument

when thus soliciting your patronage for our products is based principally on these three facts:

First, the superior and sustained quality of STANDARD products;

Second, their great variety, which enables us to meet your every requirement in the way of electric wires and cables and their accessories;

Third, our extensive and up-to-date facilities which enable us to meet your emergency demands, shipping promptly from extensive stocks located at convenient shipping points, all products not necessarily made to special order.

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ELECTRICAL ENGINEER

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5,000 Volt D. C. Electric Traction

Engineers have long been accustomed to the use of high voltages for a. c. transmission of power but it is only within the past four or five years that the matter of high voltage direct current transmission of power for railway traction purposes has been considered. The first radical departure from the 600 d. c. system, so long considered the limit for direct current operating voltages, was found in the introduction of the 1,200 volt d. c. electric railway service about five years ago. This radical departure was a surprise to many engineers and many were skeptical as to the outcome of the venture. This limiting voltage, however, was soon raised to 1,500 volts, and in the Butte, Anaconda & Pacific Ry. installation in 1913, this maximum operating d. c. voltage was raised to 2,400 volts d. c. In the system of the C. M. & St. P. electrification in Montana, patterned after this latter installation, the operating voltage was again raised to 3,000 volts d. c. Each of these new developments has been considered most radical at the time of conception, but now comes another development along this line which would seem to make all others pale into insignificance. An experimental line between Jackson and Grass Lake, Mich., is in regular operation at 5,000 volts d. c.!

This is an experimental installation and a small individual car equipment, it is true, and to some, even a perfect record of five months operation might not be considered sufficient basis for any prediction as to the possibilities of this system in connection with heavy main line electrification. Upon a closer study of the problem, however, it is found that the operation of a small high voltage d. c. unit is more difficult and more severe a test than would be the operation of a high power unit. It is not a difficult matter to insulate a large motor, for 5,000 volts, where there is ample clearance space and where a large commutator permits of liberal commutator bar insulation. But the real test of such a system is to be found in the operation of the small unit—a single car equipment, such as this experimented with on the Jackson-Grass Lake Line. Moreover, railroad officials now appreciate that one of the chief points of merit of electrical operation of steam railroads is to be found in the ability to operate small units frequently and accordingly, any system adopted for main line electrification must be able to take care of not only the high power locomotives, but also the single car or multiple car units for passenger service.

It is a remarkable fact that after five months operation, the commutators of the motors are in perfect conditions, showing no arcing whatever and even the switching units in the 5,000 volt d. c. circuit show scarcely any smoking or burning as the result of breaking the d. c. arc at this extremely high voltage. As a matter of fact, these units have much fewer marks of service in this particular than would the switching apparatus of an ordinary 600 volt car in service for a similar length of time.

The third serious problem of the high voltage d. c. railway, that of obtaining low voltage power for operating the car lights, control circuits, air compressor, etc., is taken care of in a novel manner by employing a storage battery connected in series with the main traction motors, the traction current acting as charging current for the storage battery.

It is, of course, dangerous to make any serious predictions based on the results of a single experiment, but the operating results of this trial installation are so extremely satisfactory, that we cannot but look hopefully toward the possibility of further and more extensive application of this system, which embodies the combined advantages of the low transmission loss and ease of current collection of the high voltage a. c. system as well as the lightness, flexibility and efficiency of the d. c. locomotive equipment.

The Small Gas Filled Mazda

It is a trait of human nature to make use of a new thing, often simply because it is new, rather than through any obvious merit of the article. The extensive use of gas filled Mazdas in sizes below 100 watts is, without question, open to this criticism, in view of the present state of the art.

These lamps have to recommend them for use simply an operating efficiency of but about 10 per cent better than the vacuum type Mazdas, while, on the other hand, they have the disadvantages of high intrinsic brilliancy, which injures the eyes, original cost twice as high and an average life but about one-fourth as long as the vacuum type Mazdas. So when the new lamps are stripped of their novelty features it is not only difficult to find a justification for their use, but the use of these units should be strongly condemned, at least until manufacturers have had opportunity of developing a satisfactory lamp in these sizes.

The First 5,000 Volt D. C. Railway

Three years ago trolley voltages of 3,000 to 5,000 volts were possible only with a. c. equipment, but today the 5,000 volt d. c. electric railway is an accomplished fact.

The developments in high voltage direct current railway equipment of the past three years have been most remarkable. The first departure from the standard 600 volt direct current system, so long considered the limit for railway practice, was found in the 1,200 volt d. c. system. In later installations this was raised to 1,500 volts, and in the Butte, Anaconda & Pacific Ry. installation again raised to 2,400 volts, while the main line electrification of the C. M. & St. P. Ry., in Montana is designed for operating at 3,000 volts—but yet again comes another radical increase in d. c. operating voltages in the announcement by the Westinghouse Elec. Mfg. Company of the successful operation of a 5,000 volt direct current railway between Jackson and Grass Lake, Mich.

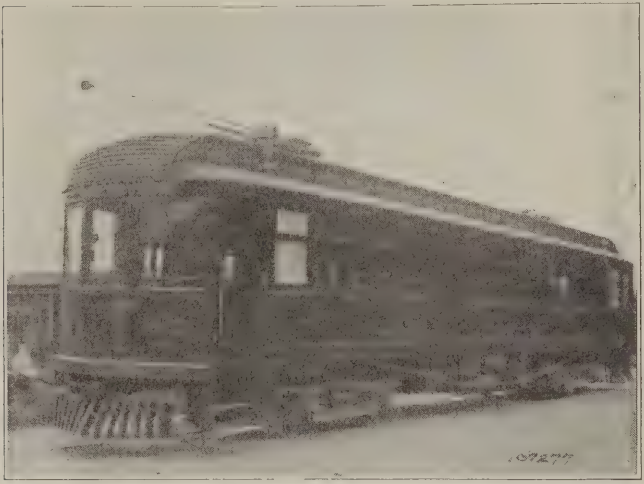


Fig. 1. Interurban Car Operating from 5000 volt d. c. Trolley on Experimental Line.

Although this installation is but of an experimental nature, it has been operating since June 1st on a more or less regular schedule, and with the exception of a few minor troubles experienced at the start, no difficulty whatever has been experienced in its operation, and there has been no delays in traffic caused by the electrical equipment of the car.

In addition to the experimental trials of the 5,000 volt motor equipment, this installation involves also a very important experiment in the operation of high voltage vapor converters of large capacity, which are installed in the sub-station and furnish the high voltage direct current. Three converters, operating from a three phase circuit, have their direct current terminals connected in series so that the resultant rectified d. c. current has a rather smooth voltage curve, due to the overlapping of the phases. This installation then is really a double experiment, proving the worth of both the 5,000 volt d. c. motor and incidentally the high voltage vapor converter.

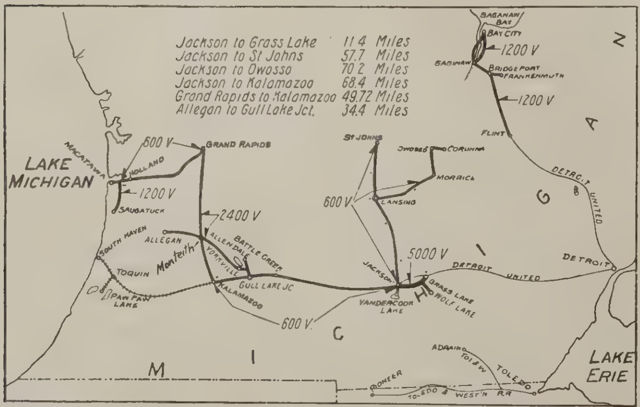


Fig. 2. An Important Net Work of Electric Railways of the Michigan United Traction Company, Showing Location of 5000 Volt Section as Well as Other High Voltage d. c. Lines.

The officials of the Michigan United Traction Company, who have been pioneers in the use of high voltages for transmission and traction purposes, gave over a section of their line between Jackson and Grass Lake and also an interurban car and part of the Grass Lake sub-station for the 5,000 volt experiment. On June 1st of this year preliminary tests were made, and after a few minor errors in wiring were corrected, the car was found to operate with entire satisfaction. Accordingly, it was consigned to regular service on the night schedule during the summer months, when a single car could perform the service, and later in the fall, when summer rush traffic subsided, this car was put into regular all-day service.

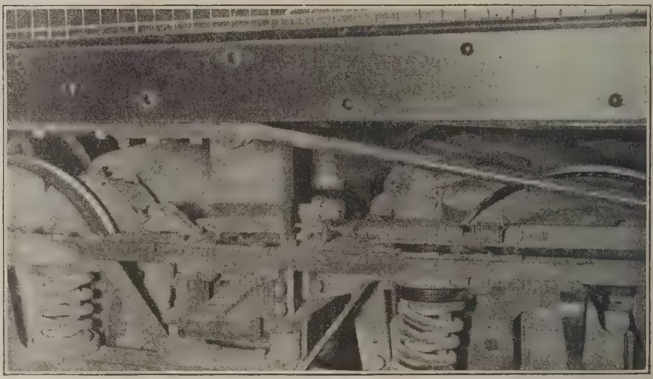


Fig. 3. A Near View of One Truck Showing Position of Motors.

It is a remarkable fact, considering the radical increase in voltage over any former installation, that there has not been a single interruption to the service chargeable to the high voltage electrical equipment on the car, and it is also most remarkable that it has not been found necessary to change any detail in the equipment since the service began.

Obviously, the most difficult features in the operation of a high voltage direct current system of this nature would be found in the motors, the high voltage switching mechanism and in the method of obtaining low voltage current for the control circuits and car lights.

On first thought it might seem that results obtained from the operation of a single car unit of small capacity would furnish no criterion for predicting results to be obtained with high power locomotives operating at the same voltage and under the same conditions, but as a matter of fact, it is much easier to build a large motor to operate at 5,000 volts than it is to build a small one. Moreover, railroad officials now appreciate that any system of electric traction which is to be used over an entire division must take care of not only heavy freight trains and heavy passenger trains, but also of the light passenger traffic, which would re-

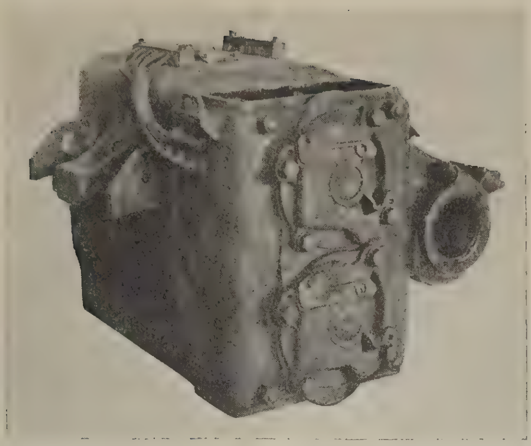


Fig. 4. Commutator End of Twin Motor. This Consists of Two Separate Armatures Connected Permanently in Series, Each with Bi-Polar Fields.

quire small multiple unit car equipments such as this experimental car. It, therefore, may be said that so far as the motors are concerned, the experiment with the single car unit is even more severe than would be experienced in the service of a large high power locomotive. It is a comparatively easy matter to design a commutator bar spacing and coil insulation when motors are to be mounted on large locomotives where plenty of space is available, but the real test of a system is to be found in the small multiple unit cars, as was employed in this experimental installation.

It is a noteworthy fact, however, that the entire equipment of this car has been installed beneath the car and without any undue crowding of the apparatus and with sufficient clearance at all points.

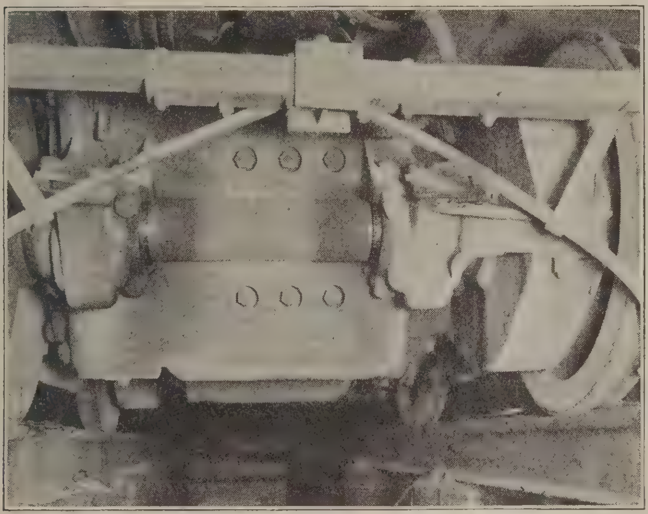
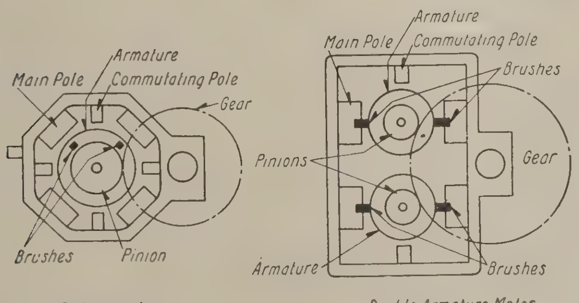


Fig. 5. Under-Body View of the Car Taken from Pit Showing Mounting of the Motor, Clearances, etc.



Ordinary Motor for 600 or 1200 Volts

Double Armature Motor for 2400 Volts or 2 in Series for 5000 Volts

Fig. 6. Comparison of the Ordinary 600 or 1200 volt Motor and the 5000 volt Motor.

Motors.

The most novel feature of the equipment is found in the use of a twin armature bi-polar motor, two separate armatures being contained in each motor frame and both armatures driving the same axle gear.

This type of motor construction has certain characteristics which lend it nicely to high voltage operation. With a given size of armature, a bi-polar motor permits the use of twice the voltage as with the same size armature in a four-pole frame. The twin armature type motor weighs but very little more than a four pole motor of the same h. p. The two armatures, being geared to the same axle, drive as a single unit and the pressure on the gear teeth is reduced to one-half.

This car is equipped with four twin motors of 100 h. p. each, and in starting the eight armatures of all motors are connected in series, as is shown in the wiring diagram of the system, Fig. 12. After the car has accelerated and the controller is thrown to the running position, the motors are operated in two parallel groups, each group having two motors (4 armatures) connected in series. Therefore, the maximum voltage impressed across a single armature is 1,250 volts.

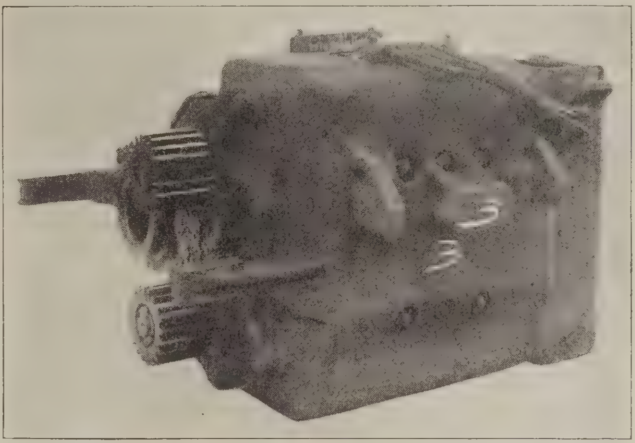


Fig. 7. Pinion End of Twin Armature By-Polar Motor. These Two Pinions Drive the Same Gear, Reducing Gear Tooth Pressure to One-Half.

The series field windings of the motors are all connected near the ground side of the circuit, therefore, the field coils are insulated for low voltage operation. The armature coils, however, are insulated for 5,000 volts.

The commutator is but 3 in. wide and has the mica between segments undercut in the usual manner. Standard carbon brushes are employed. The brushes are well insulated, having several inches of vertical creepage surface over porcelain to ground porcelain.

The total mileage by the car to date is approximately 6,000 miles, but this has been in rather severe service on account of the frequent stops and rapid acceleration. But, contrary to what might be expected, with a direct current operating voltage of so high a value, the commutator shows no arcing whatsoever. In fact, it is in perfect condition, as is shown by the illustration, Fig. 13.

Each twin motor is equipped with two commutating poles, one at the top and the other at the bottom, as shown in diagram, Fig. 6, but these two are apparently all that are necessary to give perfect commutation.

Switching Mechanism.

Another very important feature of the equipment is found in the switching mechanism. It is a simple mat-

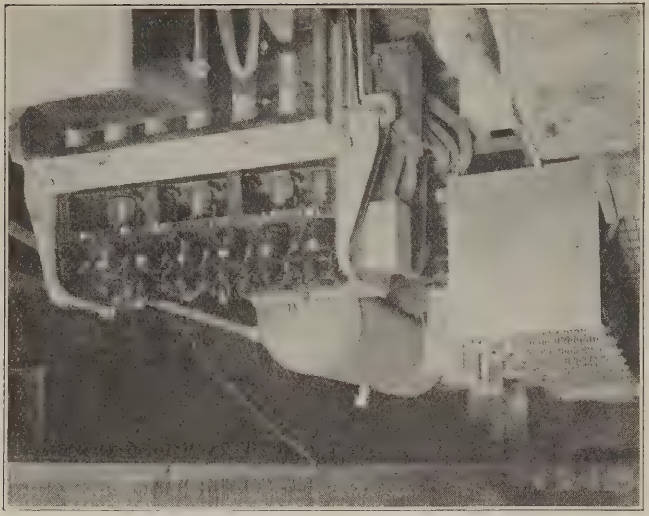


Fig. 8. Under-Body View of Car Showing One Section of High Voltage Switching Apparatus at the Left with Arc Splitter Chambers Above and Grid Resistances at the Right, Insulated for 5000 Volts.

ter to handle high voltage alternating currents by means of the oil switch, for when the voltage falls to zero, it is simply cut off by the oil film. With a direct current circuit, however, the voltage never falls to zero, therefore, the arc is maintained even in oil and the problem is a much more serious one.

This has been solved by means of a very ingenious device known as the "arc splitter." As soon as the circuit is opened and the arc forms, a magnetic blow out coil causes the arc to move out of its normal path between contacts, this being the same principle which causes a wire carrying current to move through a magnetic field. As the arc bows out, however, it immediately strikes the edge of a V-shaped piece of soapstone placed in front of the switch contacts. This serves not only to greatly lengthen the arc, but chills it and causes it to be quickly extinguished with very little flashing. As a matter of fact, the severe test of notching up the controller with all brakes set until the car circuit breaker opens does not cause nearly as much arcing on the switch contacts as would be experienced with the same test on a 600 volt car.

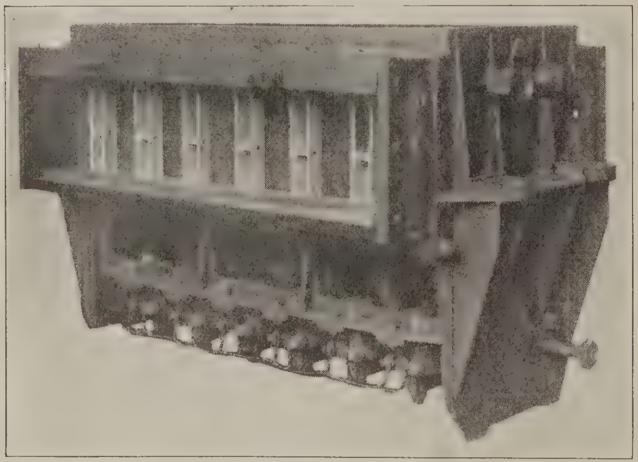


Fig. 9. One of the High Voltage Switching Groups Showing

The arc splitting chambers were carefully examined by the writer after five months' service, and they showed evidence of but very little arcing, only in one or two cases being appreciably smoked.

Instead of the usual single break switch, a double break switch is employed for the 5,000 volt circuits, as shown in Fig. 10. The contact blocks of the switches showed no beading or serious burning whatever.

The switching mechanism is located in three groups under the car, as shown in Fig. 8. The switches are closed by compressed air and opened by springs in accordance with standard Westinghouse practice. Magnetic valves control the air supply to the switch pistons and the operation of the magnetic valves is effected by the master controller.

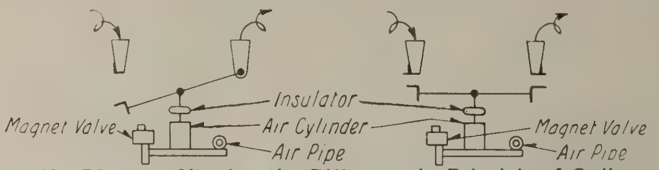


Fig. 10. Diagram Showing the Difference in Principle of Ordinary 600 Volt Switch and the Double Brake 5000 Volt Switch. Magnet Operating Valves and Air Plungers, with Arc Splitter Chambers Above.

It will be noted from the diagram, Fig. 12, that the starting resistance is located at the high voltage side of the circuit and accordingly this grid resistance is well insulated by special mountings of porcelain and mica, as shown in the under body view, Fig. 8.

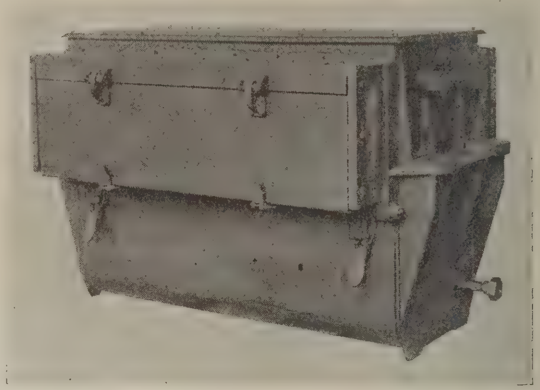


Fig. 11. The 5000 Volt Switching Mechanism with Covers Applied.

Operation on 600 Volts.

Inasmuch as this particular car must operate over the city tracks of Jackson, as well as on the high voltage division, it is arranged so as to be changed over for 600 volt operation. A change-over switch connects all four of the twin motors in parallel. This switch consists of two standard triple pole, double throw disconnecting switches with contacts mounted on porcelain insulators immersed in oil. The first notch of the controller connects all of the twin motors directly across the line without any starting resistance whatever on 600 volts. Higher speeds are effected by shunting the series fields of the motors. There are three positions for the 600 volt controller, one for starting, another for accelerating, and the third for the running position.

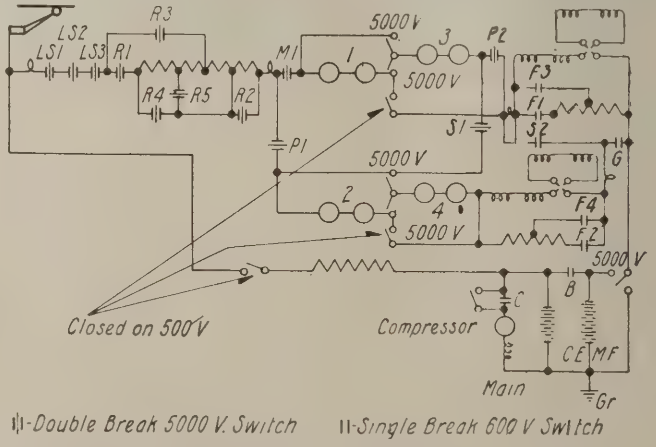


Fig. 12. Wiring Diagram of 5000 Volt Car Circuits.

Auxiliary Equipment.

The matter of obtaining low voltage current for the car lights, air compressor and control circuits is another problem of no small importance. This, of course, could be accomplished by means of a motor generator set, as done in other high voltage direct current installations, but in this case, a storage battery is installed at the grounded side of the circuit and connected in series with the traction motors so that the current employed in driving the car passes through the storage battery as a charging current.

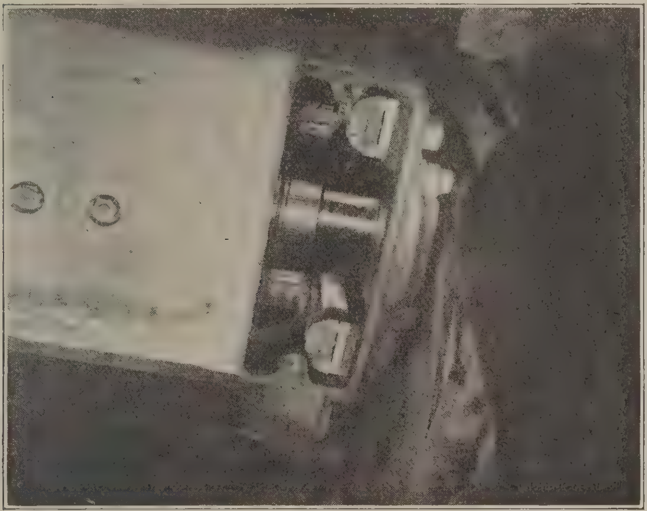


Fig. 13. View Taken from the Pit Looking Upward Into the Motor Showing the Excellent Condition of the Commutator, Brush Holder Mounting, etc.

The voltage of the storage battery selected for this purpose depends altogether upon the amount of current required for operating the lights, control circuits and the compressor while standing still. Obviously, the more power required for these the greater will be the voltage of the storage battery selected. In this case the compressor motor takes approximately 4½ k.w., the lights 600 watts, the headlight 450 watts, the control circuits about 300 watts, from which it has been calculated that a storage battery of 150 volts capacity would be required to furnish power for this auxiliary apparatus. Accordingly, 72 cells of M. V. Iron Clad Exide type are mounted beneath the car.

A double governor is provided for the compressor, one operating on high pressure, and the other at low pressure. The high pressure control operates only when 5,000 volt current is passing through the motors, the low pressure control being effective when the car is at rest. Accordingly, practically all of the power furnished to the air compressor on the 5,000 volt line is taken while the main motors are operating so that a large capacity of storage battery is not necessary.

A battery of counter e.m.f. cells are installed in parallel with the storage battery for the purpose of protecting it from heavy surges of current in starting the car. This also serves to absorb a large part of the motor current after the main storage battery has become fully charged, thereby protecting the battery from injurious overcharging. This battery of counter e.m.f. cells is disconnected from the storage battery except when the latter is charging.

Sub-Station Equipment.

5,000 volt direct current power for operating the car is obtained from one of the power company's substations, which is equipped with a bank of three steel tank mercury vapor converters. These three converters are connected across the three phases of a 3,800 volt circuit and the d. c. terminals of the converter are all connetced in series, as shown in the diagram, Fig. 14. This is probably the first time that vapor converters have ever been operated from a three phase circuit in this manner.

It is, of course, very dangerous to make predictions based on the results of a single test or a single installation, particularly in view of the radical development represented by a 5,000 volt installation. It must be recognized, however, that the operation of this experimental equipment has been entirely satisfactory from every point of view and it would indicate that the extensive use of direct current voltages as high as 5,000 volts or possibly higher, for main line electrification, is a thing of the near future. In any event, the remarkable fact remains that a standard interurban car has been equipped with four 100 h. p. motors and being operated in commercial service, has shown a perfect record over a period of 5 months' operation.

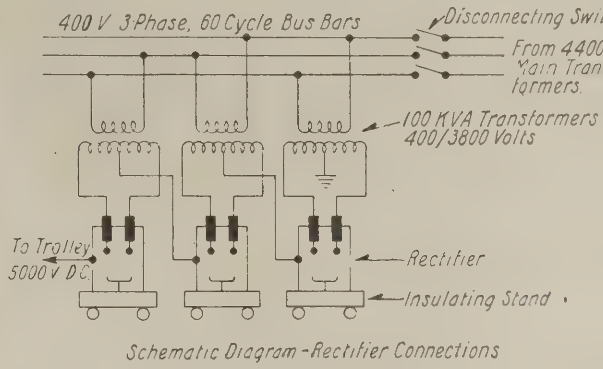

400 V 3 Phase, 60 Cycle Bus Bars
Disconnecting Switches
From 44000 V Main Transformers.
100 KVA Transformers 400/3800 Volts
To Trolley 5000 V D.C.
Rectifier
Insulating Stand
Schematic Diagram - Rectifier Connections

Fig. 14. Wiring Diagram of Converter System at the Sub-Station.

The Mechanical Problem of the Electric Locomotive.

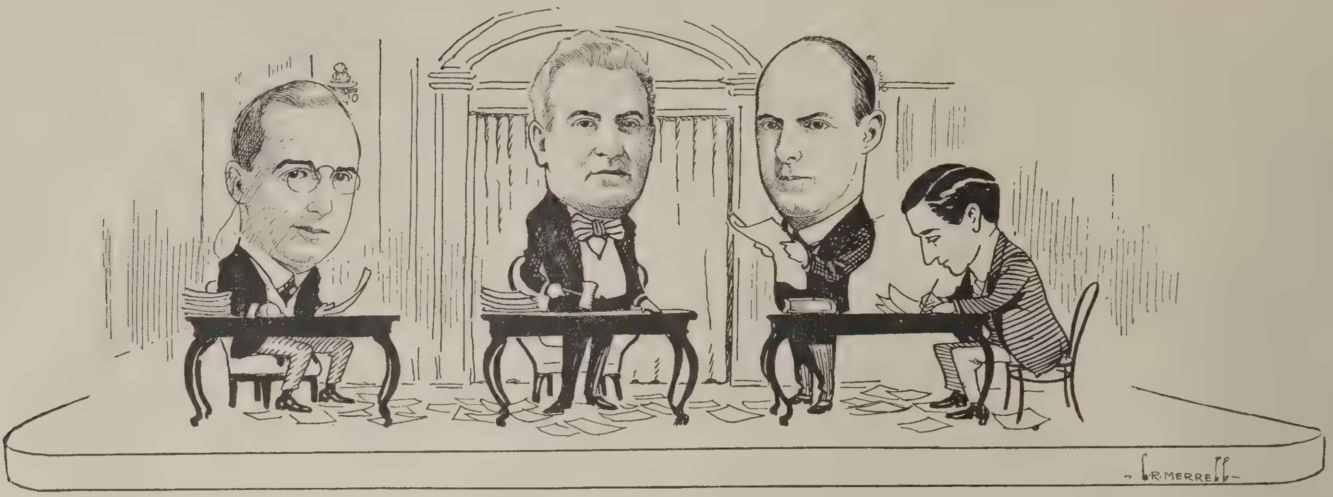
At the International Engineering Congress, which was held in San Francisco during the middle of September, Mr. G. M. Eaton, engineer in the railway division of the Westinghouse Electric Manufacturing Co., delivered a paper on the above subject.

In introducing this paper Mr. Eaton says the transmission of tractive effort from the motors to the driving wheels stands pre-eminently among the multitude of mechanical problems presented by the electric locomotive.

The stresses due the static and dynamic inter-actions of the various elements of the transmission system of crank-and-rod coupled electric locomotives was the subject of an active discussion during recent use in the Continental Technical press. An elaborate formula for the approximation of existing stresses has been developed. * * * The purpose of this paper is to approach the static problem from a somewhat different angle than has been previously employed, and to discuss a number of diagrams worked out along the lines of the suggested method of analysis.

A large part of the paper is given over to the discussion of polar diagrams showing the direction and intensity of forces acting on the different shafts.

In conclusion Mr. Eaton says the entire transmission should probably be designed to stand the maximum pressures that can be applied at any speed, in combination with the stresses inherently produced by maximum speed. The maximum pressure on each rod will vary as an inverse function of flexibility and of load and as a direct function of pin and journal clearance and of speed (with motors of series characteristics).



Report of the A. R. E. E. Convention, October 18-22, Chicago

The use of electricity in steam railroad operation is an extremely live subject and the wide diversity of subjects and equipment discussed at the annual convention of the A. R. E. E. demonstrates that the electrical men of the steam railroads are keeping abreast on this wonderful development.

Papers by Dr. Millener and J. H. Wickman on the wireless telephone and telegraph showed the present status of the matter and gave promises of some notable developments along this line.

The committee on conduit specifications reported a comprehensive outline for a series of tests in specifying conduit; the committee on wire and cable specifications presented a revision of former specifications so that the present A. R. E. E. specifications for rubber covered wire are among the most valuable and complete ever compiled.

The committee on car wiring practice presented a specification which should make future car wiring installations, the equal, if not the superior of any other class of wiring installations; the committee on illumination outlined the wonderful progress being made in lighting units. In a general discussion of ball bearings, some interesting information was brought out, both as to the method of cleaning, lubricating and life of the bearings. An instructive address on car lighting practice in foreign countries was presented; the committee on compressed air in railway shops gave some valuable information on this subject, particularly in reference to the use of a large central compressor plant versus numerous small electric driving units located near the point of consumption. The report of the committee on shop practice included some very interesting information on the use of electric furnaces for tempering high speed tool steel and also on the subject of magnetic chucks for holding materials on grinders, shippers, planers, etc. The committee on standardization of crane motors, although presenting but a progress report, clearly showed the present situation to be very chaotic and presented some interesting recommendations as to crane sizes and operating speeds.

Numerous other committee reports of interest, such as the committee on data and information, committee on standards, etc., were presented.

Committee on Standards.

After much discussion pro and con relative to the recommendations to the committee on standards, as published in the October issue of the RAILWAY ELECTRICAL ENGINEER, it was decided to substitute the report of the M. C. B. committee on train lighting, which is as follows:

"Battery boxes shall have the following minimum dimensions: Height in clear, 21½ in.; depth front to back, 2 ft. 1 in. Length of compartment to hold two standard double-compartment trays, 3 ft. 9¼ in."

"On all new and remodeled axle dynamos provided with ball or roller bearings, armature pulleys shall be in accordance with the dimensions as shown on exhibit A." (Subject to the correction of the location of the pulley web as may be decided by the M. C. B. and A. R. E. E. committees acting jointly.)

"In all new or remodeled ball or roller bearing axle dynamos the details of the pulley end of the armature shaft shall be in accordance with the dimensions as shown on Exhibit B."

"On all sleeve-bearing generators having an armature shaft less than 1⅝ in. in diameter at the inside end of the pulley fit, a taper fit of ¾ in. in 12 in. be used; the inside dimensions of the taper fit being 1½ in. with a length of 2½ in. measured on the axis of the shaft."

"On all future and remodeled ball and roller bearing axle dynamos, the roller or ball bearing in annular ball-bearing size used shall be that known as No. 412."

"That in wiring cars for electric lighting, all the wire shall be run in conduits, and the conduit shall be so installed that the wires can be pulled in and pulled out of the conduit after the car is completed."

"The generator pulley should be flanged and crowned, and have a 7-in. face. The diameter of axle pulleys should preferably be 17 in. or 21 in.; the diameter of the generator pulley should preferably be 8 in. or 11 in."

Wireless Telephone and Telegraph

Dr. F. H. Millener of the Union Pacific R. R. presented an interesting paper on the subject of wireless telephone and telegraph in railroad service. He called attention to the fact that hardly had the announcement of telephonic communication by wire from the Atlantic to Pacific been announced and put into commercial practice, before the wonderful feat of talking across the entire country by wireless telephone was demonstrated by the engineers of the American Telephone & Telegraph Company, co-operating with the government engineers. The purely technical side of the story, however, has been kept from the public, but this in no way diminishes the wonders of the feat.

He pointed out that practically all of the railroads throughout the country have been greatly interested in anything that would further protect their rolling stock and lives of the traveling public and they have made a rather extensive study of the possibilities of employing wireless in communicating to and from trains enroute.

Dr. Millener stated that he began work of this nature with the Union Pacific as early as 1906 and briefly outlined the equipment installed at the Kansas City Terminal Station, as was described in the November, 1914, issue of the Railway Electrical Engineer.

He outlined a reliability test which was made covering a period of 181 consecutive nights, the purpose of which was to determine the reliability of wireless as a transmitting and receiving medium. He stated that on every one of the 181 evenings it was possible to communicate with the Arlington, Key West and New Orleans stations, with occasional messages from Mare Island, Calif., and Galveston, as well as numerous ocean messages.

Receiving Apparatus.

Dr. Millener stated that they had numerous receiving sets for both trains and stations, each of which is equipped with two distinct sets of apparatus and five separate detectors so that if any one of them fails another can be immediately switched into circuit. He called attention to the fact that although the present high price of wireless apparatus prohibits its use by railroads, this would be automatically taken care of by a great reduction in the price of this equipment when railroads decided to use it extensively.

Dr. Millener stated he used detector audions in the receiving set, these audions being very sensitive are connected in cascade with a transformer. He explained that the audion consists of an electric light filament, the filament being lighted from one set of batteries and a grid resistance receiving current, usually from a dry cell. Dr. Millener then described a special arrangement for tuning which made it possible to switch quickly so as to receive either wireless telephone or telegraph waves.

Mr. E. A. Woodard of the Kellogg Switchboard & Supply Co., in discussing this paper called attention to the fact that the public press had recently published a story to the effect that with the application of the audion, the telephone sysem of a big ciy would be reduced to simply a box hung on the wall and this would bring us in direct communication with whomsoever we wished. He pointed out the fallacy of the story, in that a series of 400,000 different wave lengths would be required for the city of Chicago alone, to say nothing of the long distance communicating 'phones in range.

Upon being asked as to what experimental work had been done in communicating by wireless between the caboose and engine of a freight train, Dr. Millener stated there had been no definite experiments performed as yet, but said that he had this in mind and expected to do so shortly. In closing, Dr. Millener called attention to the new instrument just developed by Mr. Cooper Hewitt for the generation of continuous wireless waves.

Mr. Woodard mentioned that the D. L. & W. Ry. have been recently trying to dispatch their trains from Scranton by wireless telephone and have succeeded in getting an audible telephone conversation both ways between the dispatcher at Scranton and a passenger train conductor 90 miles away.

Committee on Wire Specifications.

The committee this year has simply added to the 1914 specifications to make them conform to the best engineering practice of the present time and to cooperate with the standardization committee of the American Institute of Electrical Engineers and to embody such work of the bureau of standards of the United States government as was possible.

Major Azel Ames, who read the report of the committee, pointed out that through this co-operation with the bureau of standards the Association received much information on copper conductivity, rubber characteristics, and many other matters having to do with electrical conductors.

On motion the report as published in the October issue of the Railway Electrical Engineer was received and with some minor corrections submitted to the letter ballot.

The report of the committee on metal conduit specifications was then read by the secretary.

Committee on Metal Conduit Specifications.

Your committee on specifications for riding metal conduit has held but one meeting. This subject is one of considerable importance and it was felt that a torough investigation of the several types of rust preventive coatings should be undertaken. One of the eastern railroads is conducting an investigation of this kind at the present time and it was felt that, inasmuch as the record of these tests will be laid before this committee, it would be desirable to not undertake any additional tests until after the results of the present tests have been studied.

The tests so far contemplated are as follows:

- Weather—Roof of building.
- Sulphur gas—Inside Roundhouse.
- Weather and sulphur gas—In Signal Bridge.
- Electrolytic action and Sulphuric acid—
  - Cinder fill—dry.
  - Cinder fill—wet.
  - Ashes—dry.
  - Ashes—wet.
- Salt atmospheric—New York Pier.
- Cracking of coating—Rattle test.
- Accelerated salt atmosphere—salt spray.
- Copper sulphate—A. T. & T. Co. Test.
- Accelerated corrosion—Humidity.
- Softening of coating—Baking oven.

Respectfully submitted,
J. L. Minick, Chairman.
J. A. Andreucetti,
C. J. Causland,
A. S. Schulman.
A. L. Chapin.

Committee on Recommended Specifications for Car Wiring.

The report of this committee as published in the October issue of the Railway Electrical Engineer was then read by George B. Colegrove, chairman. D. J. Cartwright, of the Lehigh Valley, pointed out that these specifications should be followed not only by the railroad companies in having new work done by the car builders but also by the railroad company in making its own repair work; etc.

As to the recommendation for clearances, it was decided to omit paragraph 4, relative to battery box clearance and paragraph 10, relative to suspension clearance, and substitute the following under a general head of "Clearance":

"All equipment must conform to the clearance adopted by the American Railway Association's diagram covering standard limits of clearance line for third rail and rolling equipment.

Ventilation.

In discussing the matter of the ventilation of battery box, it was pointed out by Mr. Sloan of the Penn. R. R. and Mr. Pachlay of the Rock Island lines, that four vent holes 2 in. in diameter in the bottom of the battery box at the rear, in addition to the vent holes in the battery box handles, give proper ventilation and the specifications were changed to incorporate this feature. It was pointed out that with the vent holes front and rear, at about the same level, there would not be as good a ventilating effect, as with the holes located at the top and bottom of the box.

Junction Box.

Mr. Sloan objected to the recommendation of the committee that a junction box be placed at every point where there is a reverse or double bend. After much discussion pro and con, it was pointed out by Secretary Andreucetti that the recommendations of the committee were not of a definite nature to be followed literally by the members, if adopted, but were offered simply as a guide in making specifications.

Battery Box Doors.

In discussing the matter of mounting battery box doors, E. W. Jansen of the Illinois Central, pointed out that with battery box doors hinged at the bottom, they were frequently torn off en route when the latch became loose and cover fell to the roadbed. He suggested that a heavy wooden bar (1 x 4) be mounted across the front of the batteries to prevent them from falling out in the case the battery box door is lost. Mr. Pachaly pointed out that with batteries mounted on skids there was little or no danger of them working out of the battery box and was possible where the batteries are mounted on rollers.

Generator Leads.

Mr. A. E. Voigt of the Santa Fe stated that the canvas hose covering for generator leads, as recommended by the committee, was simply a nuisance as it soon filled up with dirt and, on account of the fibrous nature of the canvas, collected much more snow and ice in the winter time than a metal surface would. He suggested that the cables be protected from flying ballast, snow, ice, etc., by some kind of a spiral metal cover.

Mr. Pachaly of the Rock Island Lines, pointed out that they have thoroughly tried out a cable made up of three conductors finely stranded, covered with jute, and a weatherproof braid and outside of this a woven wire covering made up of fine strand galvanized steel wire, woven in a spiral basket weave. He stated that this gave perfect flexibility to the cable and at the same time presented a smooth steel surface, which did not collect snow or ice appreciably.

Locker Ventilation.

The original recommendation of the committee that the lockers be ventilated from entirely within the car, was changed after some discussion, to provide that it be ventilated by a roof type ventilator at the top and through holes in the bottom of the locker door below.

Committee on Illumination.

The report of the committee on illumination, as published in the October issue of the Railway Electrical Engineer, was read by Mr. L. S. Billau. In discussing this report Preston S. Millar of the Electrical Testing Laboratories, strongly endorsed the recommendation of the committee that this committee in the future serve to keep in close touch with incandescent lamp developments, in serving as a "Go-together" between the members of the Association and the lamp manufacturers in all matters pertaining to incandescent lamps.

He pointed out an apparent error in the committee report in that it states that mazda lamps should be used exclusively, except where the greater ruggedness of the carbon and gem lamps is required. He stated that as a matter of fact, the modern mazda lamps are more rugged than the gem lamps.

As to the use of the gas filled type lamps in small sizes below 100 watts, he stated that this was very bad practice in the present state of the art and called attention to the fact that its introduction in this country was first made by foreign manufactuers, more on a sales talking point than on the actual merit of the lamps. American manufacturers were then forced to introduce these small size gas filled lamps to meet the foreign competition. He stated that the gas filled mazdas in the 50 and 60 watt sizes will have but about 10% better efficiency than the vacuum type lamps; but on the other hand, they will cost a great deal more, probably twice as much as the vacuum lamp. Economically there is no justification for the expense of the gas filled mazda in sizes below 100 watts. He pointed out, however, that having its filament concentrated and extremely brilliant, the small gas filled mazda might have a certain novelty value and also the light from this lamp being whiter, might be an advantage, although this latter point was a mooted question.

Mr. Rollinson, of the Westinghouse Lamp Co., stated that although type "C" mazdas for train lighting were not recommended by lamp manufacturers, several of the manufacturers were in a position to put these on the market in as low as the 25 watt size for 32 and 60 volt circuits. He suggested that the illumination committee consult with the lamp manufacturers regarding the shipment of various sizes of gas filled lamps for train lighting in order to eliminate a multiplicity of sizes. He called attention to the fact that the gas filled mazdas for train lighting require a somewhat smaller bulb size than has been used in vacuum lamps. He called attention to the fact that this would undoubtedly change the filament position in the reflector materially. He stated that manufacturers would be very pleased to receive an expression from the Association as to whether or not the type "C" mazda lamps were considered desirable for train lighting. He stated that some of the objections found in the gas filled mazda were the high intrinsic brilliancy of the lamp and the concentration of the filament. He stated that there is nothing about the gas filled mazda lamp in small sizes, which recommends it for train lighting in the present state of the development of the lamp. However, future developments of the small size lamps might entirely change the situation.

Mr. D. J. Cartwright, of the Lehigh Valley, pointed out that gas filled mazdas would probably find their best application in baggage and postal cars, where the G-30 bulb is now used and lamps are mounted in opaque reflectors. He suggested that lamp manufacturers confine themselves at present to the production of lamps which can be substituted for the G-30, 40 or 50 watt lamp and have the length of the lamp neck such that the filament will center on its present central position and not require any change in the reflector position when the new lamps are installed.

Ball Bearings for Car Lighting Generators.

In discussing the subject of grease suitable for ball bearings in car lighting service, Mr. Voigt stated that one type of grease known as "greoil" seemed to form a coat around the balls. He stated that the Santa Fe had also used S. K. F. ball bearing grease with satisfaction and lately have been using another grease known as "Viscosity BB." He stated that it was uncertain at the present time, however, which grease would be selected for permanent use.

As to the length of time between greasings, he stated that as an experiment they installed several bearings with but barely sufficient grease as recommended by the manufacturer and after 10 months' operation the bearing was in perfect condition with some grease left. The Santa Fe makes a standard practice of opening bearings every six months, but usually it is found that the bearings do not require the addition of more grease, so they are now of the opinion that cars can be run 12 months without greasing or further attention.

Secretary Andreucetti stated that it was a mistake to make a practice of letting ball bearings go the longest possible time without attention. For in case a bearing does begin to run dry, it quickly goes to pieces and no matter how well a bearings is packed there is always a possibility of trouble from this source. He stated that the ball bearing was certainly entitled to at least a little attention once in six months.

Mr. Pitts, of the Quebec Central, stated that 28 car lighting generators equipped with ball bearings have been operating for five years on that road and during all of this period only one bearing has given trouble. Vaseline is used as the lubricant and this is added hot so that it runs like oil and goes through the entire bearing, this being added with a funnel or a grease gun. Upon being asked as to the size of equipments, Mr. Pitts stated that the maximum capacity was 80 amperes at 24 volts, being the Stone type "D" equipment, the ball bearing of which being but 2½ in. in diameter, is somewhat smaller than A. R. E. E. standard.

Mr. E. S. Macnab, of the Canadian Pacific, stated that they have had 25 car lighting generators equipped with ball bearings operating since 1909, and during this period of 6 years, only four ball bearings have been removed; in these cases of trouble the bearing simply ran out of grease due to neglect. He stated that in 1910, 25 more ball bearing machines were installed and in 1911, 100 more, etc., so that at the present time there are 380 ball bearing Stone generators in service, with but four ball bearing failures over a period of 6 years. He pointed out, however, that inasmuch as the Stone generator operated at considerably higher speed than most of the American equipments, its armature was much lighter, so a heavy ball bearing was not required.

Car Lighting Abroad

Mr. H. D. Rohman, Chief Engineer, of J. Stone & Co., London, gave a very interesting talk on some of his experiences in car lighting in foreign countries. He stated that about 10 years ago the South African railroads lighted their cars with a scheme similar to the American headend system, an oil engine being employed and a train electrician accompanying each train on its journey. After a few of the oil engine cars burned up, the system was condemned by the railroad officials and the axle system was installed on each of the cars. At the time of its introduction, however, the railroad officials in that country, as in nearly every other country, considered electric car lighting more as a necessary evil than an art which requires proper attention and maintenance. The inevitable result was that the equipments suffered fearfully. This, however, was the cause of Mr. Rohman being sent to make a study of the operating conditions in Africa four years ago.

Battery Troubles in Africa.

Here he found numerous enemies to car lighting not found in other countries, of which the most serious one was that the dust on the road bed contained a large percent of iron. This dust, of course, found its way into the batteries, causing battery local action, discharging the battery continuously and at the same time destroying the plates. The quality of flushing water used was another serious difficulty, as this contained much decayed vegetable and animal matter, with considerable ammonia which ruined the battery plates. The railroads, however, were finally convinced of the desirability of using distilled water and with the modern sealed battery jars, both of these troubles have now been largely eliminated. Another trouble, due to the iron dust, was that it collected seriously on the outside and bottom of the boxes and with dampness from without or from the electrolyte of the battery caused serious grounds. Mr. Rohman stated that today it is very rare that a car is ever reported to be without lights on the line from Capetown to Belgian Congo.

Here Mr. Rohman discoursed on the wonders of the Zanbesi Falls located on this line. He stated that it was simply an awe-inspiring sight to see the magnificent river more than a mile wide, plunge into a narrow gorge 420 ft. below. The railroad bridge of this line crosses over the gorge 300 yards below the falls.

He stated that standard 2 k.w. machines of 24 volts capacity are employed on each of the cars together with a battery capacity of 200 ampere hours. The lamp load of the African cars is considerably smaller than that of the American railroads and the character and size of the cars are not up to the American standard.

Car Lighting in Roumania.

He mentioned a very interesting car lighting test made in Roumania and part of the Balkan States, where until four years ago the straight storage system alone was employed, the batteries being charged at terminal depots. A series of comparative tests with axle generator equipments, however, proved that this type of equipment was far more desirable and somewhat cheaper than the straight storage car lighting system under their operating conditions. The result of this experimenting is that the Roumanian State Railroads have largely given up straight storage car lighting and gone to that of the axle generator system. Mr. Rohman stated that the voltage employed for car lighting in Europe, Africa, China, Japan and India, as well as the Russian Railroads is 24 volts in all cases. He stated that with the extensive application of distilled water plants for providing pure battery flushing water over the majority of the car lighting division points in the Balkan States has greatly reduced battery troubles, so that today there are a large number of equipments on which the battery has seen more than four years' service and is apparently as good as new.

He stated that he attributed the wonderful success of the development of car lighting in these out of the way foreign lands to two main causes; first, the cooperation of the railroad officials in charge, and secondly, to the personal attention by representatives of the car lighting manufacturers, who have sent practical men into these countries to make a special study of the local conditions and overcome the difficulties peculiar to each location.

He stated, however, that unquestionably, car lighting in the United States is far superior to that in any other country. He mentioned the fact that during the eight months of his visit in this country he had never seen a dark car, this speaking volumes for the maintenance men and also for the equipment.

Car Wiring.

As to the methods of car wiring abroad, Mr. Rohman stated that for the most part lead-covered cables are laid on top of the roof with the junction boxes where the leads go down to the fittings. All underframe wiring, with the exception of Holland, is done in lead cable, but in England, simply ordinary fireproof cable is employed; in Holland all car wiring is placed in conduit. In reply to a question as to whether pasted or plante type plates were most extensively used, Mr. Rohman stated that the pasted type plate has given wonderful service in India and Africa, even where high temperatures prevailed. This type of battery is extensively used abroad.

Belting.

As to the type of belt employed, Mr. Rohman stated that usually 3 in. 4 ply, canvas belt is used; in some cases this being copper riveted, and in other cases being steel stitched. Mr. E. S. Macnab, of the Canadian Pacific, asked if anywhere in the world conditions were experienced as severe as those of Canada, where the temperature varies from 40 deg. below zero in the winter time, up to 100 deg. in the shade in the summer. Mr. Macnab called attention to the fact that these conditions tend to cause belt freezing and slipping, as well as battery freezing in the winter time, while on the other hand, excessive hot weather conditions must be encountered in the summer time, which are bad for batteries as well as belting and insulation. Mr. Rohman pointed out that in the Balkan States, particularly in Roumania and Bulgaria, conditions equally severe to those of Canada are experienced. Some troubles were experienced here due to lack of belt clearance, but the officials here were induced to offset the brake beam and since doing this, as well as removing certain steam traps near the generator, no further difficulties along this line have been experienced.

Ball Bearings.

As to the use of ball bearings abroad, Mr. Rohman stated that they had been used most extensively during the past 4 or 5 years and during the past 4 years no trouble whatever has been experienced. He pointed out that the question of grease is a very important one, it being desirable to select a grease of a high melting point as well as having other desirable characteristics.

Mr. Wray, of the Railway Electrical Engineer, inquired as to whether or not it has been found necessary to employ two different grades of grease, one for winter operation and the other for summer operation. He stated that in many of the American generators particularly those opened in the early spring, he had noted a large cake of unused grease remaining in the grease chamber, this having taken no part in the lubrication of the bearing because of the fact that it was frozen solid. He asked if it would not be advisable to add a spoonful of oil to ball bearings in the fall or warm them up occasionally with a steam hose in cold weather in order to work the grease into the bearing.

Mr. Rohman stated that this had not been found necessary to his knowledge on the Stone generators on account of the fact that the heat of the generator, even in cold weather, was sufficient to warm the grease to a viscous point. He pointed out that it would be very good practice to grease the ball bearings once every 3 or 4 months, but to remove the bearing for cleaning only once in 12 months. He pointed out that it was extremely dangerous to remove the bearing plate for inspection on account of the liability of dust being blown into the bearing, this causing the balls and races to become pitted.

Committee on Compressed Air Generation.

The report of this committee, as pulished in the October issue of the Railway Electrical Engineer, was then read by Mr. E. Wanamaker, elec. engr. of the Rock Island Lines, chairman. In discussing this report Mr. Wanamaker stated that the committee had considered the advisability of using the variable stroke compressor in preference to other unloading devices, but on account of the increased maintenance required, thought it inadvisable to recommend this type of equipment. Mr. Gardener of the C. B. & Q. R. R., stated that it was very common practice to install but one air compressor unit in a shop, whereas there are nearly always two and sometimes three duplicate electrical generating units provided. He stated that it would be only wise engineering practice to provide duplicate compressor units located at opposite ends of the main pipe line so as to balance the load and each one serve as an auxiliary to the other.

Mr. Wanamaker pointed out that he personally had spent five months investigating the problem as to whether the centralized air compressor plant with air pipe feeder lines is more economical than numerous motor driven compressor units scattered about the shop. The result of this investigation was that neither system showed any great advantage over the other. He pointed out that very frequently poor maintenance of the compressor is the cause of high steam consumption by these units, this being due to worn valves, etc. It was very seldom that any leaks occurred in the main distributing line after this has been once properly installed, but that a large amount of leakage occurs in the small pipe lines leading off the main distributing lines.

Electric Furnaces in Railroad Shops.

S. F. Sikes, ch. elec. of the Sunset Central Lines, described some oil burning furnaces for tempering tool steel installed on that road, in which the capacity of the old coke furnaces had been quadrupled and far better results were obtained.

Mr. McKelvey stated that a pyrometer had been used with excellent results in oil blast furnace work, although for the finer grades of tool steel the electric furnace alone was employed. He stated that there are several advantages in using the electric furnace over the oil or coal furnaces; first, that with the electric furnace, with pyrometer, it made it possible to very accurately control the degree of heating so that there is no danger of burning or spoiling the tools. Moreover the furnace is kept entirely closed so that oxidization of the metal is prevented. By applying the heat uniformly on all sizes in an electric furnace the heating of the steel is much more uniform and better results obtained. Furthermore, several pieces can be heating at the same time without air burning the outer pieces of steel. In some cases where preheating of the steel is required, this can be done at a very slow rate up to 1,200 or 1,800 deg. F. with an electric furnace, whereas, it is not possible with the other types of furnaces.

In reply to a question as to the cost of electric furnaces, Mr. Wilson, of the Union Pacific, stated that electric furnaces are of two classes, the one for high speed tools being a high temperature furnace, and the other for carbon steel tools being designed for operation at a lower temperature. He stated that the Union Pacific have recently installed one of each type and the total cost amounted to about $1,100.00.

Election of Officers of A. R. E. E.

The annual election of officers of the A. R. E. E. resulted as follows:

President, E. W. Jansen, elec. engr. Illinois Central R. R.

1st Vice-president, C. J. Causland, ch. elec., Penn. R. R. Lines West.

2nd Vice-president, J. E. Gardner, elec. engr., C. B. & Q. R. R.

Secretary-treasurer, J. A. Andreucetti, gen. fore., C. & N. W. R. R.

New members of Executive Committee—E. Wanamaker, elec. engr., C. R. I. & P. R. R.; E. S. Macnab, engr. elec. car lighting, Can. Pac. Ry.

Place of Meeting Next Year.

It was decided that the semi-annual meeting would be held at the same time and place as the June meeting of the Master Mechanics' and Master Car Builders' Associations and that the annual meeting of the Association be held in Chicago, the date to be selected by the executive committee.

Election of Officers of the R. E. S. M. A.

At the annual meeting of the Ry. Elec. Supply Mfgrs. Assn. the following officers were elected to serve for the ensuing year:

President, T. L. Mount, Consolidated Ry. Elec. Ltg. & Equip. Co.

Senior vice-president, F. F. Skeel, Crouse-Hinds Co.

Junior vice-president, Azel Ames, Kerite Ins. Wire & Cable Co.

Secretary, J. Scribner, General Electric Co.

Treasurer, Edward Wray.

Members of the Executive Committee—W. F. Bauer, Edison Storage Battery Co.; R. M. Newbold, Willard Storage Battery Co.; J. H. Rodger, Safety Car Htg. & Ltg. Co.

Manufacturers' Exhibits at the A. R. E. E. Convention

Oct. 18-22, Chicago

Albert & J. M. Anderson Company had on exhibit a complete line of charging plugs and receptacles for coach yards, coach mounting and switchboard mounting. They also exhibited a time switch having a variable capacity of from 5 to 200 amperes for controlling the lights in small stations where an agent is not maintained at night. The time switch automatically switches on the lights a few minutes before the arrival of each train and turns them off shortly after its departure.

Mr. W. W. Hincher represented the company at the convention.

American Pulley Company exhibited a new pressed steel armature pulley made up in the form of standard American pulleys, the rim being composed of two pressed steel parts riveted to the flange.

They also showed their tapered axle bushing and split, pressed steel axle pulley with both the straight and flare flanges, the latter being for use in connection with the body hung generators.

Mr. John Forrest and C. P. Englehart represented the company at the convention.

Adams & Westlake Company's exhibit of lamps were mounted on a display board arranged in the shape of the side and ceiling of a car, as has been their custom for some years in the past, so that all units are mounted in a position similar to that which they occupy in actual service.

Among the new things which were shown this year, were several types of unity fixtures. These are cast in one piece so that there is no chance of loose parts interfering with its operation. Roundhouse lighting fixtures were also shown, as well as their regular display of half-deck lamps, recessed, vestibule reflectors and a large variety of berth lamps.

The company was represented by Messrs. A. S. Anderson, C. B. Carson, W. J. Piersen and J. F. Stender.

Benjamin Electric Manufacturing Co. Three large panels of Benjamin lighting specialties gave a general idea of the large variety of equipment that this company makes for the railway field. On one board was shown a complete line of sockets; another exhibited a variety of porcelain receptacles and some of their gas and vapor proof specialties; on the third, there latest styles in suspension fittings were to be seen.

Several new fixtures for mazda "C" lamps were on exhibit for the first time this year. These were both of the deep and shallow bowl type and constructed of drawn steel.

A complete line of reflectors with "S" type holders was shown. These can be used with "Benco" sockets and outlet box receptacles and covers, the complete line being interchangeable. A new fitting was exhibted which adapts any of the "condulets" to the complete line of Benjamin fittings with the type "S" holders.

The company representatives were Messrs. H. E. Watson, G. B. Weber and A. E. Lubeck.

Central Electric Company exhibited a complete line of their Okonite wire. The exhibit room was illuminated with an Alexolite unit and special attention was called to the good general illumination that this provided. Several units of Berylite glassware were shown and four types of Maxolyte lighting units. Other of their products on exhibit were a variety of sizes of D. & W. fuses and Ralco plugs and receptacles.

The company was represented at the convention by Messrs. J. M. Lorenz, E. C. Wilson, D. Woodhead, R. N. Baker, A. L. McNeil and L. G. Martin Okonite Co.

Consolidated Railway Electric Lighting & Equip. Co. exhibited one of their 2-kw., 40-volt, 50-ampere, interpole, ball bearing generators, which was equipped with an improved type of pole changer. A type "L-3" generator regulator with ampere-hour meter control was mounted for inspection and their type "L" lamp regulator was also exhibited.

Messrs. T. L. Mount and W. R. Hungerford were the company's representatives.

Crouse-Hinds Company had on exhibit for the first time this year their new motor starting switches for induction motors. They showed a complete line of their railroad condulets, including those for mail cars, coaches, baggage cars and yard charging installations, as well as a large number of their products which are suitable for general industry purposes. On panel boards condulets for car lighting work and building installations were shown. Several round house lighting reflectors and marine fixtures were also displayed.

Messrs. F. F. Skeel, W. Fagan, C. Dubsky, E. C. Otto, A. F. Hills, M. J. Kiefer and C. H. Bissell were the company's representatives.

George Cutter Company exhibited several types of their street lighting fixtures and their industrial lighting reflectors which go under the name of Sol-Lux. The McWilliams metering panel board models which were shown are used for changing meter circuits in large office buildings without the necessity of changing the wiring.

The company was represented by Messrs. O. B. Duncan and F. L. Carl.

Darling-Henrici Mfg. Company exhibited this year for the first time at this convention. They had on exhibit a complete incandescent locomotive headlight equipment, mounted so as to show the constructional details. They make these equipments in the 250, 350 and 500 watt sizes for either 6½ or 32 volts. The one kw. size is designed for either 32 or for 110 volts.

Messrs. L. A. Darling and M. S. Jordon represented the company.

Edison Storage Battery Company in their rooms exhibited a large number of their nickel iron cells mounted on pedestals. Each of these cells had different portions cut away so as to show all of the structural details. A new feature, a new type of button suspension trays was on exhibit this year, knobs are welded onto the sides of the cells and these rest in rubber buttons which are built in the tray. In this way electrolysis is prevented even if the tray and cell should become unduly moist.

A panel board with the component parts of the Edison cell showed the method of building up each separate unit.

The company representatives were Messrs. H. G. Thompson, W. F. Bauer, F. V. McGinness and C. A. Luckey.

Electric Storage Battery Company exhibited their new condensed car lighting switchboard in which the contactor is combined with the automatic switch. A new type of suspension bearing saddle, which was exhibited, is a big improvement over the former suspension. This rests on top of the suspension bar and is held in place by four vertical bolts which pass through a plate on the under side of the bar.

Messrs. J. L. Woodbridge, H. E. Hunt, G. H. Atkin, O. R. Shortall, T. Milton and H. M. Beck were the company's representatives.

Franklin Railway Supply Company, who were at the convention for the first time this year are introducing the American-made Stone car lighting equipment. This has found extensive use in most of the countries of the world except the United States and this is the beginning of their campaign to introduce it here.

Representatives of the company were W. H. Coyle, H. D. Rohman, R. G. Coburn, C. W. F. Coffin and Joseph Sinkler.

Gould Coupler and Gould Storage Battery Companies exhibited their standard simplex regulator panel consisting of both generator regulator and lamp regulator. They also had on exhibit of a 1 kw. generator which was partly dismantled. In addition to this were shown numerous generator parts and a specially mounted pole changer, which clearly showed the operation of this unique device. One of the Gould stoneware jars was also shown. The latter was accompanied by several new type wooden jar separators which provided that all pressure or stress of one jar on another would be transmitted by means of the separator only at the front or back end or opposite the center web, where the crushing strength of the jar is extremely great.

The company was represented by Messrs. G. R. Berger, M. R. Shedd, and J. W. Jepsom.

General Electric Company had on exhibition types of their starting compensator, Novalux lighting fixtures, and a cable testing outfit. A steam flow meter also excited considerable comment. They exhibited samples of their fabroid gears which are made up of fabric which has been soaked in oil. They are claimed to be very rugged and silent running.

The company's representatives were Messrs. B. F. Bilsland, J. Scribner, C. S. McCune and E. H. Bailey.

Hart & Hegeman Manufacturing Company. On two panel boards exhibited a variety of different types of railway snap and push button switches, as well as indicating switches, which show when the circuit is being used. These have application for small power and heating circuits. The second panel board showed a variety of Paiste pipe taplets. A large variety of conduit fittings in both large and small sizes were also shown.

The company's representatives were W. W. Winship, H. L. Everest, Jr. and F. C. Church.

Harter Manufacturing Company had an exhibit of lighting fixtures with the characteristic Harter individuality. Their room was one of the brightest spots on the floor, due to one of their DeLuxlites, a new all-white, self-reflecting fixture which they installed. Another feature was the new hinged Nitrolite. These, together with the Ⓡ sign,—get it?—their Railroad Folder, the Harter Line train crew and other original stunts did not disappoint those who look every year for something out of the ordinary from Harter.

The train crew were composed of Gus Harter, Bill Soffe and "Doc." Ayers.

Kerite Insulated Wire & Cable Company kept open house in their reception booth, and their company was represented by Messrs. B. L. Winchell, Jr., Major Azel Ames, P. W. Miller, G. A. Graber, W. H. Fenley and J. A. Hamilton.

Krantz Manufacturing Company, exhibiting at this convention for the first time, showed an interesting line of their brush type switchboards. A large switchboard panel had mounted on it several units of this type of switch. These are recommended especially for high tension work in that the switchboard presents a dead front and uniform handles are placed in uniform positions. Two types of panel boards were shown, one with an emergency relay that throws the circuit from one source of power to another in case of failure of the first, or gives both audible and visible signals, as may be desired. One of their safety panel boards for car lighting was shown. Panel boards with mounted knife switches, connectors, laminated studs, nuts, washers and switchboard fittings exhibited their products, which are of interest in this field. Special attention was called to a 600-volt safety car lighting switch.

Mr. I. A. Bennett represented the company at the convention.

Mutual Electric Company had an interesting exhibit of their storm wave motion fans. By means of an irregular gear the fan is caused to oscillate up and down and the resultant gyroscopic action causes the fan to oscillate side ways, causing the air currents to be sent in a great variety of directions with no regular sequence. This motion can be limited or adjusted and units are made which are suitable for dining car, Pullman and other classes of train service.

Mr. Paul E. Ellguth represented the company.

National Lamp Works, by means of an automatic stereopticon machine showed a large number of views of industrial installations of mazda lamps and several unusual lighting installations such as flood lighting of tennis courts, picture studio lighting, as well as views of the home office and development laboratories.

On a rack was shown a complete line of train lighting lamps, locomotive headlight lamps and a variety of gas filled lamps.

The representatives of the company were Messrs. C. W. Bender, A. M. Klingman and L. C. Kent.

National Metal Molding Company exhibited several display boards showing a complete line of their products. On one display board a typical installation was represented which called for the use of a large number of fittings of this line of materials. It was used to illustrate the flexibility and ease of installation of this material.

On other display racks were shown National outlet boxes, enamel conduit, Sherarduct, Economy conduit, flexible steel conduit, flexible tube and a complete line of fittings for same.

The company was represented by Messrs. H. C. Moran and I. A. Bennett.

Oneida Steel Pulley Company exhibited their new clearing flange axle pulley for use in connection with body hung generators, the angle of flare being such as to permit a considerable variation in the angle of drive without cutting the edge of the belt.

They also showed their standard axle pulleys and corrugated bushings for fitting tapered axles. Mr. N. G. Stark represented the company.

Pyle National Electric Headlight Company had an exhibit of both their type "K" 300 watt incandescent headlight and their type "E" 1,500 watt standard arc equipment. There were numerous novel features about the former which were of interest and various dismantled parts were shown in explaining its operation. The rotor wheel buckets are so designed that the path of the steam instead of being in a plane perpendicular to the shaft is in a plane parallel to it. A quadruple expansion nozzle is provided which forces the steam to pass through the rotating buckets four times and a marked economy in steam consumption is effected.

The company representatives were Messrs. W. Miller, J. W. Johnson, C. P. McGinness, J. E. Kilker and W. T. Brotherton.

Railway Electrical Engineer, as usual, was located at the Convention Headquarters, and were represented by Messrs. Edward Wray, C. D. Sperry and Miss Estelle Pearce.

Safety Car Heating & Lighting Company exhibited one of their new under-frame generators having parts cut away so as to show the generator construction. They also showed their standard generator and lamp regulator panels and a few car lighting fixtures, both of the direct and semi-direct type.

The company was represented by Messrs. A. C. Moore, G. Hulse, W. I. Thompson, C. A. Pinyard, J. L. Marsh and J. A. Rodger.

Sangamo Electric Company showed a complete line of their ampere-hour meters for all classes of train lighting service. Alternating and direct current watt-hour meters for industrial installations were also shown, both of the service and switchboard types. An unassembled meter showed the constructional features. A graphic ampere-hour meter was also on exhibit.

The representatives of the company were M. C. Southwick, J. T. Hartley and C. H. Koehler.

Schroeder Headlight Company made their first exhibit at this convention. They had on exhibit both a 6 and 32-volt equipment with cover removed so as to show the constructional details and to give an idea of the principle of operation. The points which the company emphasizes about this equipment are the simplicity and accessibility of the mechanism and the ruggedness of construction. Ball bearings are used throughout and a square thread extending along the shaft on either side of the bearing is used as the grease retainer and serves to force grease to the bearing.

Messrs. J. H. Schroeder and E. H. Werzner were the company's representatives.

Standard Underground Cable Company exhibited a full line of elastic wires and cables in various forms of insulation and finish. They also exhibited a line of copper clad wire and some cable accessories, such as high tension terminals, pot heads, junction boxes, etc.

The company was represented by Messrs. E. G. Pietzcker, W. M. Rogers, H. K. Weld and E. F. Norton.

U. S. Light & Heat Corporation exhibited three different sizes of car lighting generators, the type "A," 1 kw.; the type "B," 2½ kw., and type "C," 4 kw. One of these was equipped with a flangeless armature pulley but stationary belt guides were provided to keep the belt in proper position. This pulley instead of having standard perforations had numerous grooves cut into the pulley face in order to allow for the escape of air and thus provide good belt adhesion.

A new parallel link type suspension was shown which was equipped at all wearing points with replacable shafts and bushings so that no wear whatever could come directly on the suspension itself. On a large panel board were mounted various parts to show construction, some of these had sections cut away which illustrated the operation of the equipment.

The Bakelite mounted commutator was shown in sections and partly dismantled. A new lamp regulator panel was exhibited and some of the novel features about this were roller bearing and contacts of the lever on carbon pile, and air dash pot with Bakelite rings and Bakelite piston, the latter having a ball and socket. The Bakelite composition for this dash pot is made up with a liberal quantity of graphite in its composition so that the resultant product has nearly the strength of pure Bakelite and the non-friction qualities of graphite.

The U. S. L. bearing mounting and lock plate were also exhibited separately. This rigidly mounts the inner race of the bearing on the shaft and the nutlock locks the shaft lock-nut and tapered bushing rigidly together. Another interesting part of the exhibit was a collection of the parts necessary to convert an old generator of the sleeve bearing type into one of the ball bearing type. A new type of car lighting battery was also on exhibit which is made up considerably less in height than standard. This battery was made up of 11 plates 6x14 in., with a 14-in. horizontal dimension. The over all length was 32 in. for a double compartment tank of 350 ampere-hour capacity and the over all height is 15 in.

Another special car lighting battery was on exhibit. This consisted of a 7 plate cell of 175 ampere-hour capacity made up as 4 cells per tray, the over all dimensions of the tray being the same as the standard battery.

The representatives of the company at the convention were as follows: Messrs. A. J. Matthews, C. C. Bradford, A. W. Donop and John Rodell.

Western Electric Company had among their new exhibits a newly developed train announcer for calling trains in the station, which is claimed to be unusually clear and especially suitable for this class of work. Mazda "C" lamps in sizes from 100 to 2,000 watts were also exhibited.

Marshmallows toasted while you wait were served from a toy electric range.

The company was represented by Messrs. G. H. Porter, J. C. Binning, T. J. Rider and B. W. Greene.

Westinghouse Lamp Company had no exhibit but made a reception room of their headquarters.

Representatives of the company were W. H. Rollinson, A. N. Brown and J. G. Harvey.

Willard Storage Battery Company exhibited several types of their no wash battery. To show the constructional features, a ¼ section of one battery had been cut away exposing a horizontal cross section of the plates. A small pilot lamp concealed from the eye eliminated this surface and a magnifying glass mounted above it, made it easy to see how the plates were formed. Lead sealed covers for these batteries were also shown and by means of two special tools for demonstrating that these covers could be removed in less time than a rubber cover can be removed.

The company's representatives at the convention were W. E. Ballantine, R. M. Newbold, E. L. Meyers, L. Sears and Miss McAnallen.

Progress on the Electrification of the Chicago, Milwaukee & St. Paul Railway

Construction work on the electrification of the western lines of the Chicago, Milwaukee & St. Paul Railway has been prosecuted most actively since the initial order for equipment was placed with the General Electric Company in September of 1914. In view of the magnitude of this project, the progress made to date has been remarkable.

The overhead construction, which will include 650 miles of single track, has been completed for a distance of more than 200 miles. The 100,000 volt transmission line being erected by the railway company to parallel the electrified tracks has been completed for an equal distance, and tie-in lines from the 100,000 volt system of the Montana Power Company are ready for service. The trackage now ready for train operation includes extensive yards and sidings at Three Forks, Deer Lodge and Piedmont and passing tracks at other points. The rail bonding crews have followed the overhead construction gangs completing the ground circuits.

Illustrations show the general appearance of the new type of trolley construction and transmission lines. It

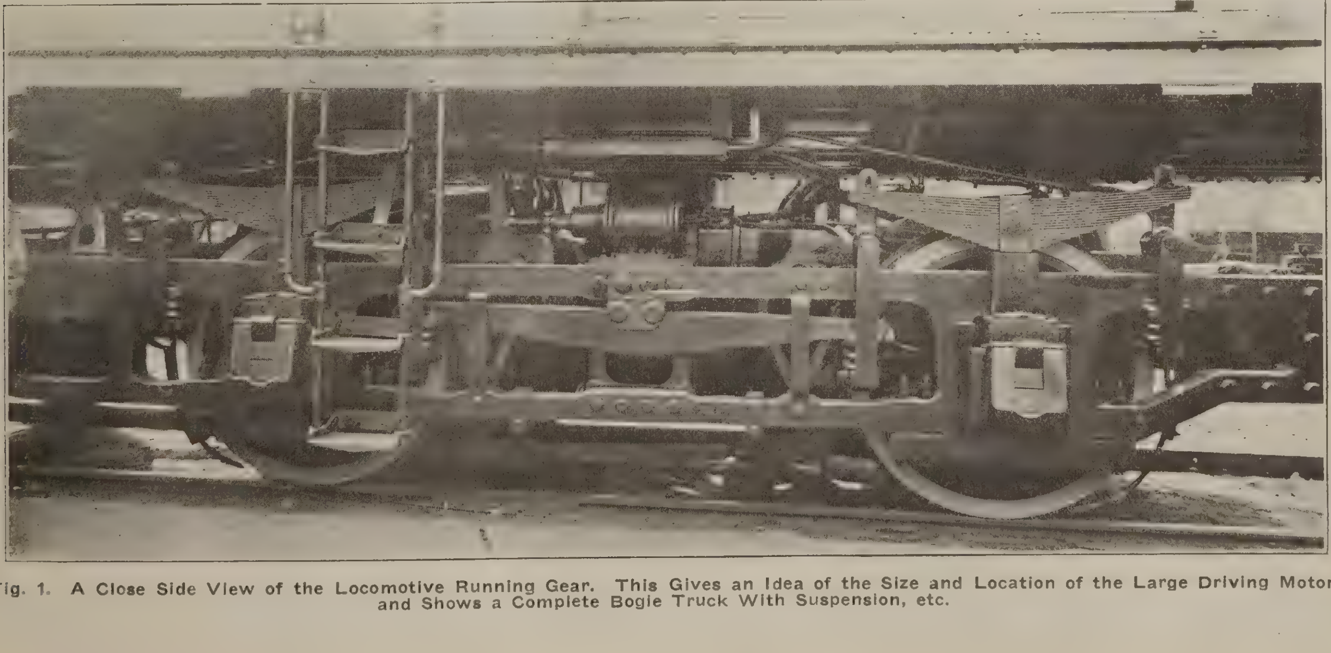


Fig. 1. A Close Side View of the Locomotive Running Gear. This Gives an Idea of the Size and Location of the Large Driving Motors and Shows a Complete Bogie Truck With Suspension, etc.

will be noted that wood-pole construction is used throughout both for cross span and bracket construction. The twin 4/0 trolley wires are suspended individually and separately from the same steel catenary and the hangers of one trolley wire are located at points mid-span on the other. In the switching yards only one trolley wire is used.

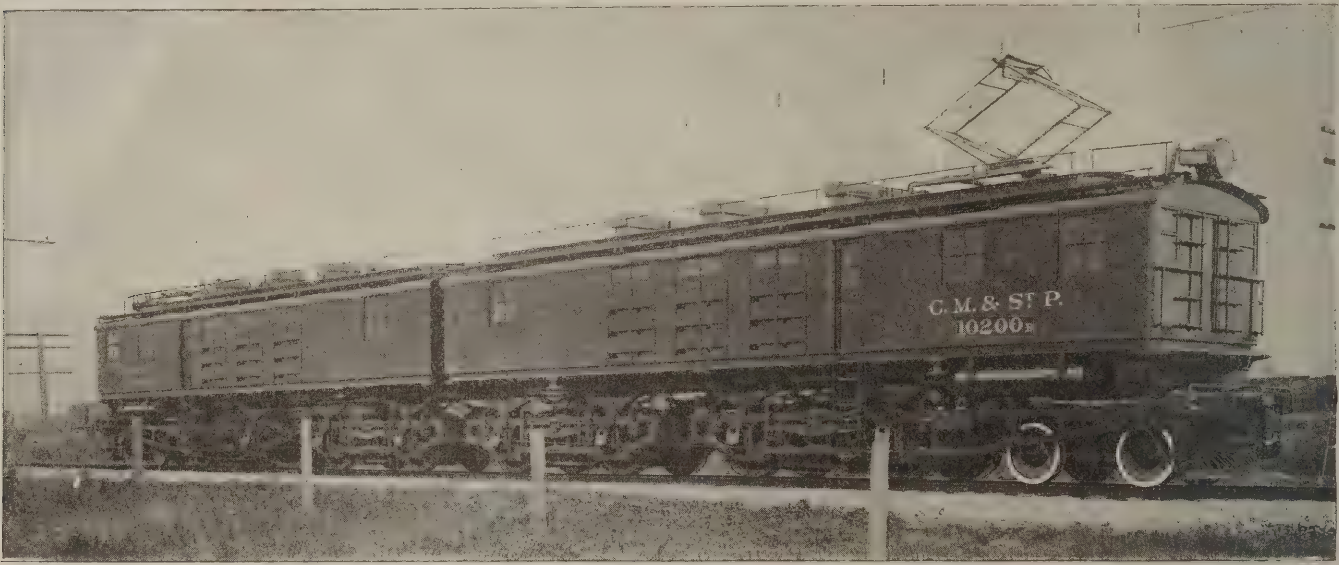


Fig. 2. First of the 42 280-Ton, 3,000-Volt Direct-Current Locomotives on the Test Tracks of the General Electric Co. at Erie, Pa., Works.

Substations.

Seven substations designed to supply power to the first half of the 440 miles of route have been completed and electrical equipment is being rapidly installed. Complete shipments of transformers, motor-generator sets, switchboards and other accessories have been made by the General Electric Company, Schenectady, N. Y., U. S. A., for the stations first erected, and the equipment of four substations is practically ready for operation. Construction cews are proceeding with the erection of the remaining seven substations shown on the profile between Deer Lodge, Montana, and Avery, Idaho.

Table of Substation Equipment.

		Motor Generator Sets.			Transformers.	
Sub. Name.	Miles from Avery.	No. Units.	Size K. W.	Total. K. W.	Sizes. K. V. A.	Total. K. V. A.
Two Dot....	425.6	2	2,000	4,000	2,500	5,000
Summit.......	392	2	2,000	4,000	2,500	5,000
Josephine....	361.8	2	2,000	4,000	2,500	5,000
Eustis..........	331.8	2	2,000	4,000	2,500	5,000
Piedmont....	289.1	3	1,500	4,500	1,900	5,700
Janney........	261.7	3	1,500	4,500	1,900	5,700
Morel..........	228.3	2	2,000	4,000	2,500	5,000
Gold Creek	192.7	2	2,000	4,000	2,500	5,000
Ravens.........	160	2	2,000	4,000	2,500	5,000
Primrose.....	122.2	2	2,000	4,000	2,500	5,000
Tarkio..........	85.6	2	2,000	4,000	2,500	5,000
Drexel..........	47.5	2	2,000	4,000	2,500	5,000
East Portal	23.7	3	2,000	6,000	2,500	7,500
Stetson........	3.6	3	1,500	4,500	1,900	5,700
		32		59,500		74,600

Motor-Generator Sets.

Each of the motor-generator sets consists of a 60 cycle, 3 phase, 2,300 volt synchronous motor direct connected to two 1,500 volt direct current generators. The generators are connected permanently in series to supply 3,000 volts to the trolley. Each set is also provided with an exciter at each end, one providing excitation for the revolving field of the motor and the other supplying the separately excited fields of the d-c machines.

These sets are in general similar to the five 1,000 kw., 2,400 volt units in operation on the Butte, Anaconda & Pacific Railway except as regards voltage and capacity. One new feature, however, has been added which deserves mention. This consists of a longitudinal ventilation of the core and field coils similar to that employed in the well-known GE ventilated railway motor. The use of this method of cooling has effected a considerable reduction in the floor space required per kilowatt.

The d-c. generators are equipped with commutating poles and compensated pole face windings to insure sparkless commutation under heavy overloads. This overload capacity is 150 per cent normal load for 2 hours and 300 per cent normal load for periods of five minutes. This will provide ample margin for starting a train of maximum tonnage on the most difficult grades.

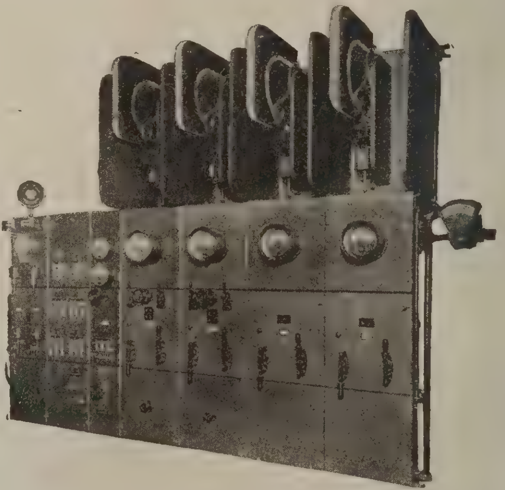


Fig. 3. Type of High Voltage Switchboard Which Will be Used in the Different Sub-Stations.

It is interesting to note in connection with these substations that the motor-generator sets are designed to operate inverted in case the regenerated power exceeds that required by other trains operating nearby. For this reason, there is no necessity for water boxes or other energy consuming devices, since the excess energy is transmitted to the 100,000 volt system.

Switchboards.

The main direct current switchboard in each station is of special interest, since it represents the latest practice in high voltage direct current switching apparatus.

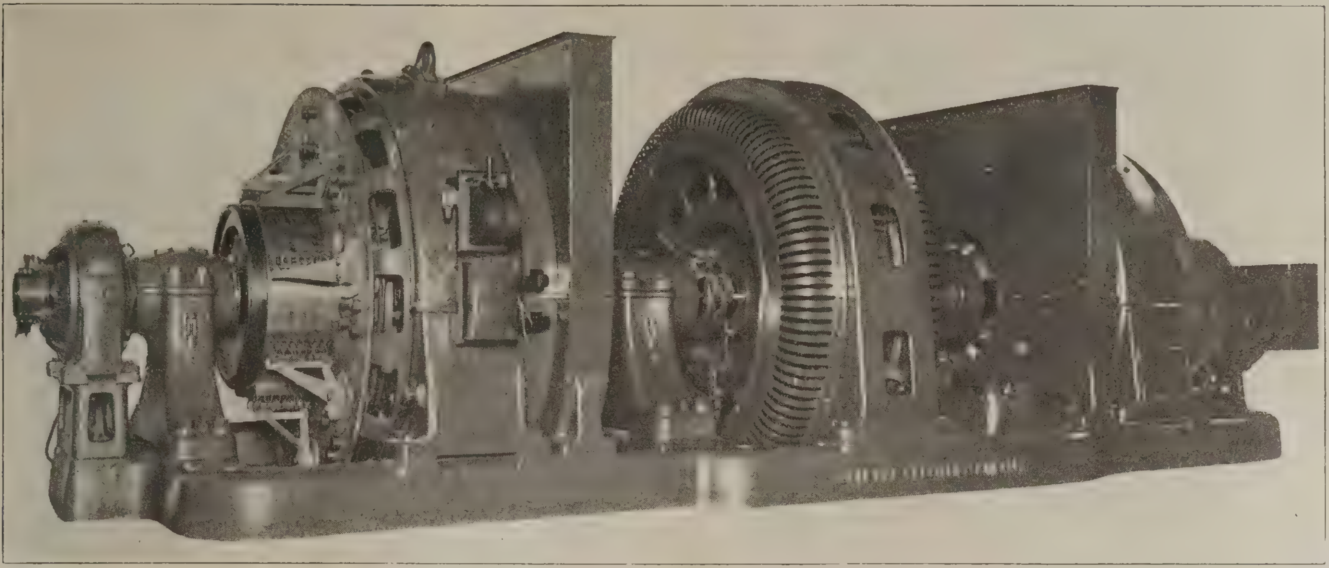


Fig. 4. A 2,000 k.w. 3,000 Volt d.c. Motor Generator Set.

A panel is provided for each set and two panels are provided for feeders in each direction.

The circuit breakers and switches are mounted on separate panels located above and a short distance back of the main panels, similar in general to those now operating in the Butte, Anaconda & Pacific substations. The control handles for operating the breakers and switches are located on the main panels and are connected to the circuit breaker panels through insulated wooden rods.

In addition to the special high voltage d-c panels, switchboards are also being furnished for the synchronous motors and auxiliary circuits. Oil switches and other standard 100,000 volt equipment are also being installed for the high tension circuits.

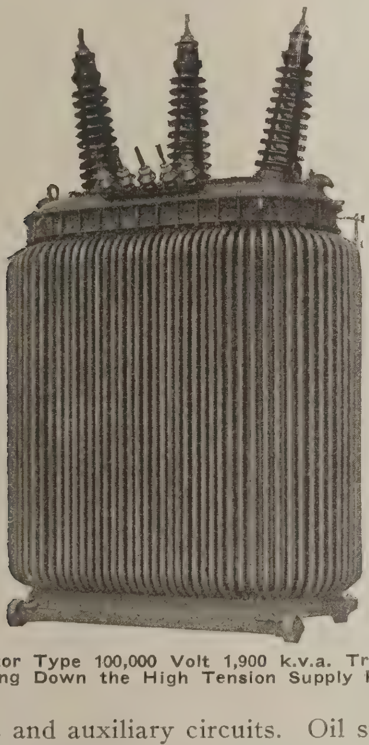


Fig. 5. Radiator Type 100,000 Volt 1,900 k.v.a. Transformers for Stepping Down the High Tension Supply Power.

Transformers.

The transformers, which are under construction in the Pittsfield Works of the General Electric Company, are an example of the most recent design and construction. There are a total of thirty-two of these units which are to be used for stepping down the power supply from the 100,000 volt transmission line to 2,300 volts as required for the synchronous motor-generator sets. These transformers will be installed in fourteen substations, which will furnish power for the entire electrification from Harlowton, Montana, to Avery, Idaho. There are twenty-three 2,500 kv-a. and nine 1,900 kv-a. units located as shown in the accompanying table.

These transformers are all of the 3 phase core type with a ratio of voltages of 102,000 to 2,300. For regulating purposes taps are provided for 97,200 volts and 94,200 volts. Taps are also brought out on the secondary windings to give 1,150 volts or half voltage for starting the motor-generator sets.

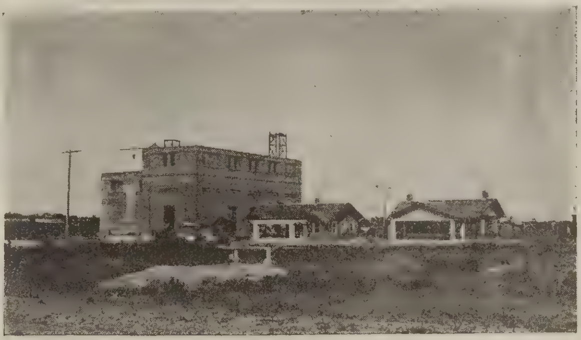


Fig. 6. Sub-Station at Two Dot, Located at the Extreme Eastern End of the Electrification.

The transformers are oil cooled and the tanks are of the tubular type, the main body consisting of steel plate with tubes welded to the side of the tank at the top and bottom giving absolutely oil-tight joints. An air dryer and breather is attached to the tank so that all interchange of air between the interior of the tank and the outside must take place through this channel. This dryer is provided with chambers containing a moisture extracting medium thereby preventing the entrance of moisture to the tank.

The bushings furnished with these transformers are weatherproof and as all joints are tight, they are suitable for outdoor as well as indoor operation. At the top of the high tension oil filled leads is a glass cup which shows the height of oil in the leads. Accessories consisting of thermometer, oil gauge and drain valve are also provided. Each transformer is mounted on flat wheels to facilitate movement for making re-

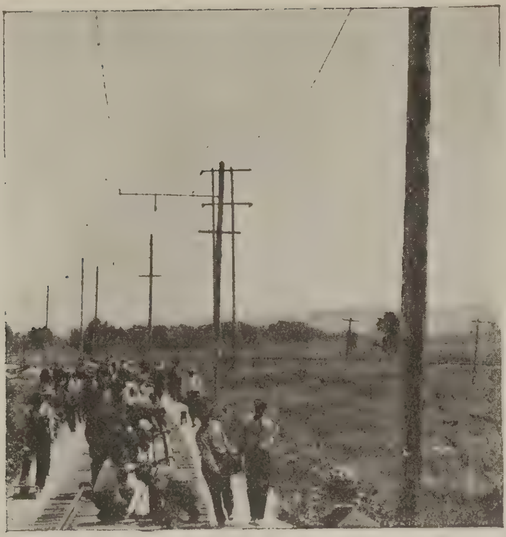


Fig. 7. Single Track Curve Showing the Overhead Line Construction. Construction Crew is Bonding the Running Rails.

pairs and a lifting device is furnished for removing the transformer core.

Auxiliary Transformers.

In addition to the main transformer equipment, each substation will be furnished with a standard 10 kw., 3 phase transformer stepping down from 2,300 to 110 volts for lighting and auxiliary power circuits.

For operating the railway signal circuits, a standard 25 kw., single phase transformer is being installed in each substation stepping up from 2,300 to 4,400 volts. A portable oil drying outfit will be used for removing moisture from the transformer oil. This outfit consists of a motor-driven pump which forces the oil through an especially designed filter and the electric drying oven for drying the filter paper. A portable transformer dryer and an oil testing set will also be supplied.

For housing the families of the substation operators, a four-room and five-room bungalow is being constructed at each station and these will be furnished with light and power from the low voltage auxiliary circuits.

Locomotives.

Work on the construction of the forty-two 282-ton locomotives for this electrification is progressing rapidly at the Erie Works of the General Electric Company and in the Schenectady plant of the American Locomotive Company. The first complete locomotive was placed on the test tracks early in September and shipment was made as scheduled on September 25th. This locomotive has been taken in charge by the railway company at Chicago and is now being exhibited at various points on the Chicago, Milwaukee & St. Paul system under the direction of Mr. C. A. Goodnow, assistant to the president. A complete set of tests indicate that the locomotive will easily exceed the expectations of the designers.

The actual weights of the completed freight unit are as follows:

Total	564,000 lb.
Weight on Drivers	448,000 lb.
Weight per Driving Axle	56,000 lb.
Weight per Guiding Axle	29,000 lb.

Twelve of the locomotives on order are geared for passenger service and the remaining thirty are geared for freight service. Both freight and passenger types are equipped for regenerative braking, this apparatus being under control of the engineer. All of the passenger locomotives and several of the freight locomotives will be equipped with oil fired steam boilers for heating the passenger trains. This equipment will include ample storage tanks for oil and water.

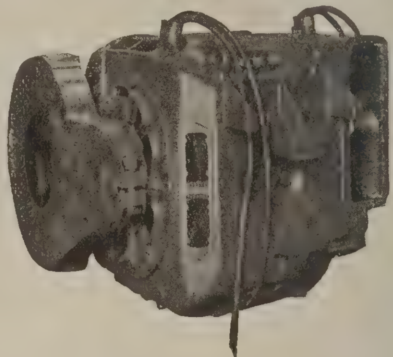


Fig. 9. One of the 430 h.p. 3,000 Volt Motors Used for Driving the Locomotives.

The locomotive which is just being delivered and was recently exhibited in Chicago is similar to those which are under construction. This locomotive is designed for freight work in the Rocky Mountains and will give its highest efficiency in the coldest weather

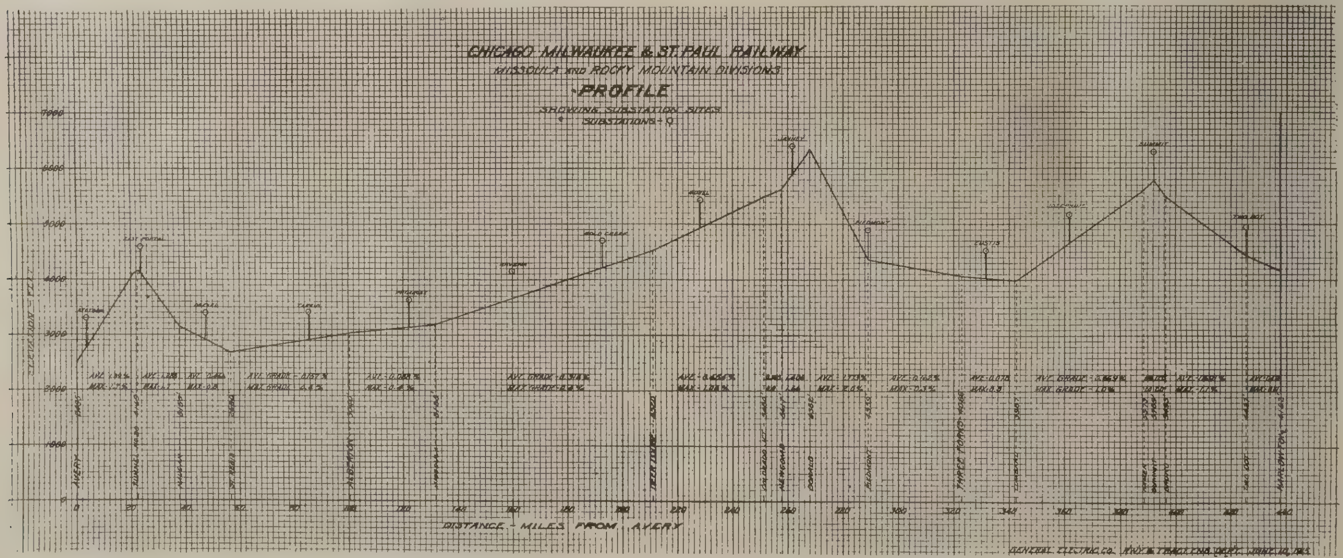


Fig. 8. A Profile of the Electrified Division of the C. M. & St. P. Ry. Showing the Location of the 3,000 Volt Direct Current Sub-Station.

which is quite contrary to the operation of steam locomotives in this service. Inspection is required only once for every 1,000 miles of travel and it carries no tender, has no boiler, uses no coal, and requires no water except a small amount for operating the oil fired steam heaters for heating passenger cars.

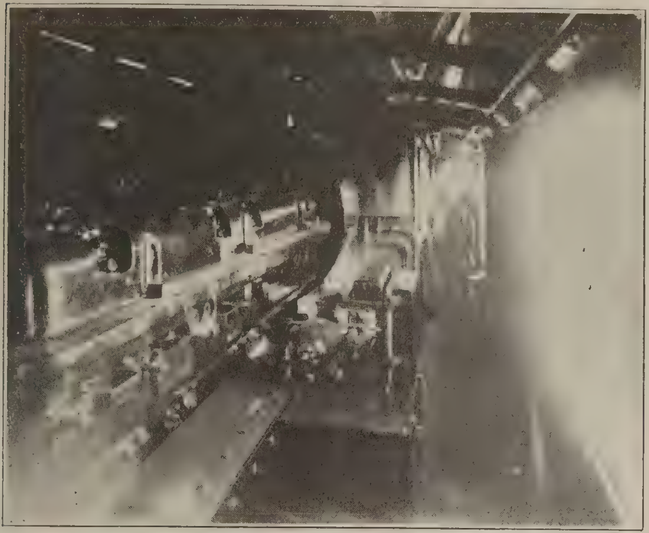


Fig. 10. The Large Motor Generator Set Found in Both Units of the Locomotive. 3,000 Volt Double Commutator Motor Drives Large Sirocco Ventilating Fan Shown at Opposite End and Two Direct Low Voltage Generators.

The weight of the electric locomotive is 94 per cent that of a combined Mallet engine and tender and has a tonnage rating of 23½ per cent greater and a speed and drag tonnage of approximately 57½ to 96.8 per cent greater.

The regenerative control feature of this locomotive enables the motors to run as generators on down grade and send back to the line about 30 per cent of the energy used in pulling the train up grade. This results in uniform speed on both up and down grade and makes the use of air brakes unnecessary, except in cases of emergency and eliminates the danger incident to worn brake shoes and overheated wheels.

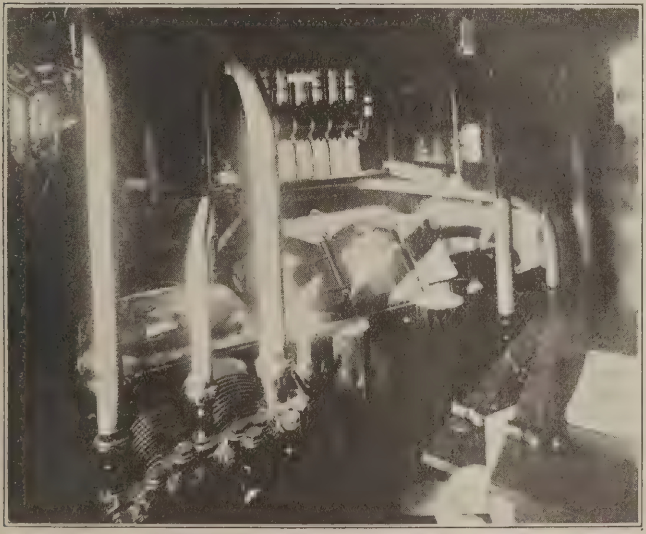


Fig. 11. Aluminum Cell Electrolytic Lightning Arresters Shown Above and Motor Driven Air Compressor Below.

The two units which make up a complete locomotive are exact duplicates of each other and are coupled together in the center and both operated from either end of the combined locomotive, so a description of one unit will suffice for both.

In the forward end of the locomotive the operator's control apparatus is placed. The control provides for three efficient running speeds and a position for regenerative braking. The usual air brake control apparatus is also provided. Passage ways lead from the front down either side directly back of the controllers. Directly back of the operator there is a large motor generator set. This large motor-generator set consists of an 86 kw. double commutator motor running at 3,000 volts, a 40 k. w. low voltage double commutator generator used to excite the motor fields during regenerative braking and on the same shaft an 8 kw. 125 v. d.c. generator to operate control, lighting, headlight, etc., has the two sets of brushes connected in series so that only one-half the line voltage is applied. Direct connected to the rear of this driving motor is a large Sirroco air blower, shown in the center of Fig. 9, which supplies air for the forced ventilation of the main drive motors. All the remote control apparatus and the starting resistance are placed in the center of the locomotive unit. The design is such that all portions of the control are apparatus available for inspection and repair at all times. The switching apparatus comprises electrically operated contactors for all the resistance points on the controllers and electropneumatically operated change over and reversing switches. The two latter functions are performed by compressed air but all other functions are taken care of, electrically as in the regular G-E. Multiple Control. The aisles which pass on the outside of the car expose sheet steel doors which can be removed to permit access to the back of the remote control switches which are also accessible from the elevated center aisle which passes through the locomottive at this point.

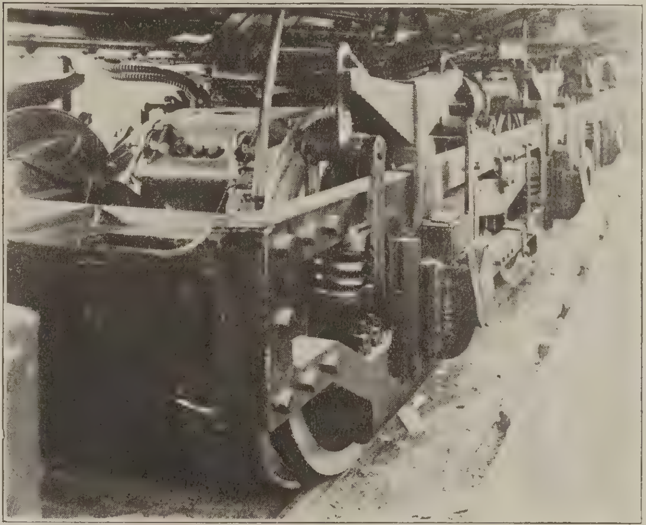


Fig. 12. End View of One of the Locomotive Driving Trucks Showing the Motor and Enclosed Gear Casings.

The air which is supplied to the drive motors is drawn from the interior of the locomotive and ventilators are placed in the center of both sides of the locomotive unit so that the incoming air serves to cool the remote control apparatus.

The inner end of the unit contains the motor driven air compressor consisting of a 30 kw. double commutator motor operating at 3,000 volts driving a three-cylinder air compressor.

The capacity of the set is 150 cu. ft. of air per min. at 130 lbs. gage.

The lightning arrester consists of 12 aluminum cell arresters connected in series. Fig. 11 shows the air compressor and lightning arrester.. A large choke coil connected in series with the supply line prevents dangerous current surges from injuring the apparatus.

Drive Motors.

The eight main drive motors are divided up into four pairs, each pair being permanently connected in series. This provides three efficient running speeds, viz., with the running in series; two parallel sets each made up of 4 motors operating in series and with the four pairs of motors each pair being connected in parallel across the line.

The motors that are used on this locomotive are of the type known as G. E. 253-A and are built for 1,500 volt operation but are insulated for 3,000 volts. The wheel diameter is 52 inches.

The motors which are used in this locomotive have the specifications listed in the table below:

Type	G.E.-253-A.
Voltage	1,500
Insulation	3,000
Wheel diameter, inches	52
Armature length, inches	29.5
Length of core, inches	12
H.p. rating, 1 hr	430
Amp. rating, 1 hr	240
Amp. rating, continuous	210
5 min. amp. rating, 30% coef. of adhesion, amperes	330
Cu. ft. air per minute	1,750
Copper loss, 1 hr. rating, watts	14,400
Copper loss, continuous rating, watts	11,000
Copper loss, 5 minute rating, watts	27,300
Core loss, 1 hr. rating, watts	7,400
Core loss, continuous rating, watts	7,150
Core loss, 5 minute rating, watts	8,360
Gear ratio	4.56
Gear teeth	82
Pinion teeth	18

The motor efficiencies are as follows:

1½ load,	90.5%.
Full load,	90.0%.
¾ load,	88.7%.
½ load,	86.0%.

At full load the temperature rise is 35 deg. C. and at 150 per cent load the temperature rise is 55 deg. C. The specifications require that insulation of the motor armature and field shall stand a test of 5,000 volts and that the generator armature shall stand a test of 6,000 volts.

Fig. 1 and 12 show how the motors are placed on the locomotive frame as well as other details of the locomotive construction.

Shop Motor Section

Electrically Operated Voltage Control

Twelfth Article.

Hand Control.

Direct and alternating current generators do not have inherent voltage regulation, and unless some auxiliary apparatus is used, the voltage will vary considerably with the load. To control the voltage so as to keep it fairly constant, it is necessary to use auxilary apparatus that will control the field excitation of the generator, and thus control the generated voltage of the machine. By compounding a generator the voltage can be kept very nearly constant but it is not as positive as external regulators. The common 110 volt direct current generator will give 110 volts, under normal operating conditions, under certain conditions and the maximum voltage may be as high as 150 volts due to change in speed or excitation and it may vary from this to any value down to zero.

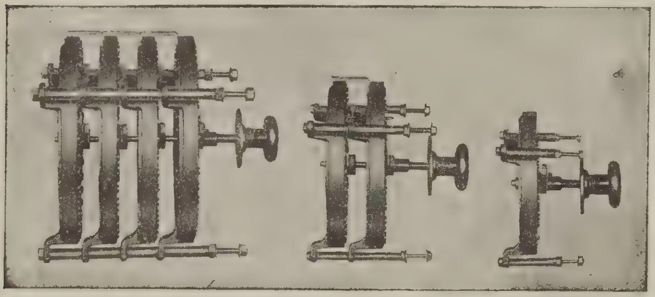


Fig. 29. Three Types of Hand Regulated Rheostats for Switchboard Mounting.

It is the purpose of this article to describe definite types of control apparatus that have been used to keep the terminal voltage of the generators constant. It is especially important in lighting that the voltage be kept constant, for a small variation is very noticeable. For small machines, a very usual method is to carry the field resistance, and in this way control the voltage.

Field Rheostats.

A rheostat that is suitable for voltage regulation should be durable, it should not be affected by heat and should have a sufficiently large number of steps

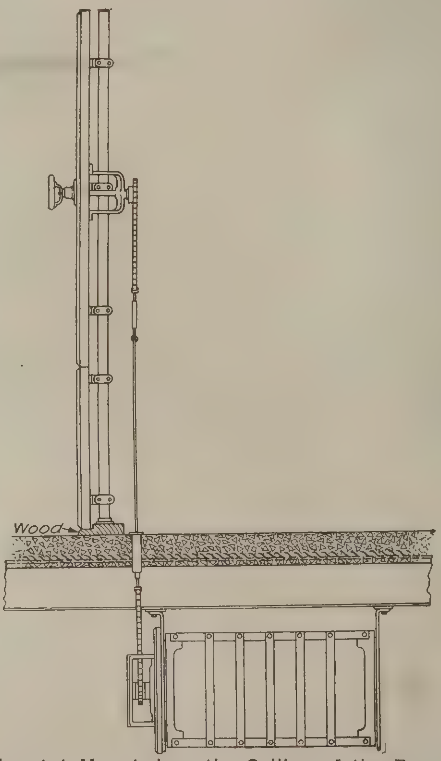


Fig. 30. Rheostat Mounted on the Ceiling of the Room Below the Switchboard. The Regulating Wheel on the Board Operates the Rheostat by Means of a Sprocket and Chain.

to vary the resistance gradually and to control the voltage increments within the desired limits. There are several different types of field rheostats, known as the hand, sprocket, gear, ratchet and motor driven. For small installation the hand operated type shown in Figure 29 is most usually employed.

Every rheostat should have enough resistance so that when it is all inserted in the shunt field of the generator, the voltage of the machine will be reduced, practically to zero.

Rheostats for small machines are usually mounted upon the rear of the switchboard by means of projecting studs, with the controller handle extending through on to the front of the board. When rheostats are used which weight too much to hang on the board, they are placed on the ceiling of the room below, or on the switchboard supports above the board as shown in Figure 30. This latter method has the advantage on account of the accessability for inspection and repair. With this mounting a sprocket wheel is fastened to both the operating handle and the rheostat proper, and the connecting chain is used as a means of transmission. With the larger sized rheostats the contactor turns too hard to be manually operated. An ingenious method of operation in such a case consists of an electromagnetic rachet. With this equipment the rheostat can be placed wherever it is convenient in relation to the board and generator.

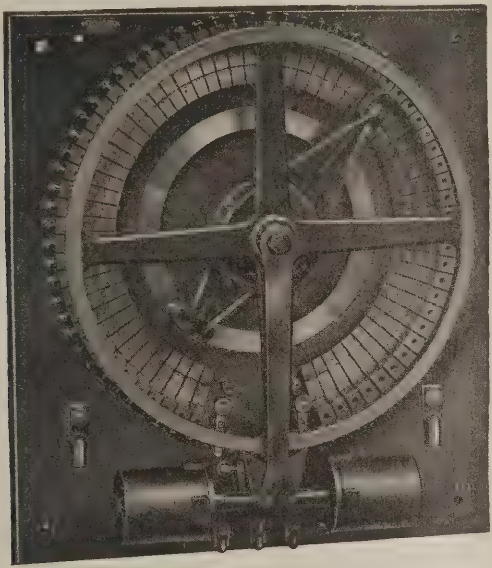


Fig. 31. Ratchet Adjusted Rheostat Operated by Two Solenoids Shown With Their Plungers Attached to the Ratchet Arm.

As shown in Figure 31 the ratchet is operated by two solenoids which face each other, and actuate the ratchet by means of movable plungers and connecting links. The operator has a single pole reversing switch which raises the voltage in one position and lowers it in the other. The current for operating the solenoids is supplied from the busbars or from a storage battery.

For very large rheostats a motor control is provided. The controlling current is furnished in the same way as in the previous case, and the motor is controlled by a double pole reversing switch placed upon the switchboard. The motor by means of a worm and wheel regulates the resistance.

Care of Rheostats.

The field rheostat is, as a rule, the most neglected piece of apparatus in the station, and the only time that it receives attention is when failure has occurred, To issue good operation the rheostat should be kept clean, and free from all accumulations of dust and dirt by frequently blowing it out with compressed air. The bearing that supports the handles of the sprocket wheel should be occasionally oiled. One of the chief causes of trouble is due to grounds in the rheostat, which are usually caused by the dirt which is allowed to collect. Obviously grounds cannot interfere with the action of rheostat, so the grids should always be kept free of grounds, should be well insulated from the casing supporting them. The small contact points frequently give trouble, due to their surfaces becoming hard and pitted. These are replacable however, and if they are given a thin coating of vaseline occasionally, trouble will seldom occur from this source.

D. C. Automatic Regulators.

An automatic regulator has been designed to keep the terminal voltage of the generators constant at all times, irrespective of the ordinary load fluctuations or changes in the generator speed. It may also be used to compensate for the line drop by increasing the voltage as the load increases. The advantages of this type of regulator may be summed up as follows:

1. It cuts down the number of attendants required in large stations, for with hand control several men were required to keep the voltage adjusted.
2. There will be a decreased number of lamp renewals required, because with automatic regulation the voltage will not be allowed to increase above its proper value.
3. Higher efficiency lamps can be used where the voltage is kept steady than where it is allowed to vary.
4. A loss in station revenue will occur with low voltage, and this is obviated by means of the automatic regulator.

Principles and Construction.

The operating and construction features of the regulators which will be described below have reference to the type of regulators which control the voltage by opening and closing a shunted circuit across the field rheostat of the generator instead of varying the field resistance. When the rheostat is short circuited by this shunt the generator voltage rises at once. The higher voltage then breaks the circuit and the operation is repeated. By means of the vibrating contact the voltage will tend to rise and fall each time the rheostat is short circuited, and the effective value of the voltage will be dependent upon the frequency of the vibrations, and the greater average length of time that shunt is closed the higher the voltage.

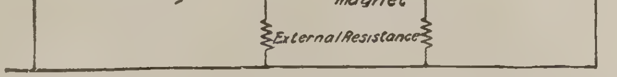


Fig. 32. Diagrammatic Sketch of Automatic Voltage Regulator. By Means of a Series Coil it Compensates for Line Drop.

The regulator consists of a main control magnet with two independent windings and a differential wound relay magnet. One winding of the control magnet, known as the potential winding is connected across the generator terminals and the other winding is connected across a shunt in the main line from the generator. The latter is the compensating winding and it opposes the action of the potential winding so that as the load increases, a higher potential is maintained at the generator to over-compound for the line drop. In practice the potential winding is connected to the busbars and the compensating shunt is inserted in one of the principal feeders from the station. A diagrammatic sketch of this regulator is shown in Fig. 32.

The control magnet has an adjustable stop core at the bottom and a movable core at the top. The movable core is attached to a lever operating the main contacts, the pull of the magnet being opposed by a spiral spring which tends to keep the main contacts closed. The relay magnet has a U shaped core and its armature operates the contacts that open and close the shunt circuit across the field rheostat. The differential windings of the relay magnet are permanently connected through a resistance to the busbars, the circuit is being made through the main contact of the control electromagnet. When the main contacts are open the relay contacts are also open. The relay contacts which open and close the shunt circuit across the field rheostat are protected against sparking by a condenser connected in parallel with them.

Sequence of Operation.

The shunt circuit around the generator field rheostat is temporarily opened by means of a switch located on the base of the regulator panel and the rheostat turned to a point that will reduce the generator voltage to about 35% of its normal value. The main control magnet is at once weakened the spring pulls the movable core out so that the main contacts are closed, which closes the second circuit of the differential relay, thus neutralizing its windings. The relay spring then lifts the armature and closes the relay contacts. The switch in the shunt circuit across the generator field rheostat is now closed, practically short-circuiting the rheostat, and the generator voltage at once rises. As soon as the voltage reaches a value for which the regulator has previously been adjusted, the main control magnet is strengthened. This causes the main contacts to open which in turn opens the relay contacts across the rheostat. The rheostat is now in the field circuit, the voltage at once falls off, the main contacts are closed, the relay armature released and the shunt circuit cross the rheostat is again completed, after which the voltage starts to rise, and so completing the cycle of operations.

The compensating winding on the control magnet which opposes the action of the potential winding is connected across an adjustable shunt in the principal feeder circuit. As the load increases the voltage drop across the shunt increases and the current through the compensating winding becomes greater. So a higher voltage will be required on the potential winding to open the main contacts. The regulator in this way causes the generator to compensate for line drop, maintaining at the busbars a steady voltage without fluctuations, which rises and falls with the load on the feeder. A constant voltage is thus maintained at the lamps or center of distribution.

These adjustable compensating shunts are made to adjust for any line drop up to 15% and the adjustments are made by sliding a movable contact along the shunt, the contact being made so as to be clamped at any position. The terminals of the relay coil of the main control magnet are usually run back from the center of distribution.

There are several types and forms of this regulator on the market and are applicable to the voltage regulation of either shunt or compound wound generators.

The connections shown in Fig. 32 are applicable to the regulation of one machine only, but where there are several operating in parallel the one machine that is in connection with the regulator would take care of the fluctuations of the entire load of the station. This is an objection to the use of automatic regulation where direct current machines are in use. The use of a regulator on each machine would overcome this difficulty so that the load would be divided proportionly among the machines.

The next article will deal with the regulation of alternating current generators and feeders both hand and automatic.

The Principles of Alternating Currents

Williard Doud

(*Eighth Article.*)

In the preceding installments of this series considerable has been said regarding the effect of wattless currents in an alternating current circuit. It has been shown that the ability of an alternating current generator to furnish power for performing useful work depends upon the power factor of a circuit, the given power factor value representing the percentage of the rated capacity of the generator which is available for productive purposes.

When current is purchased little attention is given, as a rule, to the power factor of the apparatus installed but where energy is generated as is the case in a majority of railroad installations, it is important that every means available be utilized to maintain a high power factor on the distribution circuits.

Low power factor in a system as a general rule, may be attributed to the use of motors, transformers and other energy consuming devices with inductive characteristics which are not being operated at or near the rating for which they were designed.

To illustrate the effect of operating certain apparatus unloaded or partially loaded, the following tabulation is presented showing the power factor of a modern induction motor of certain size on various percentages of full load rating.

	Power Factor Per Cent of Full Load Rating		
	50	75	100
7½ h. p., 440 volt, 3 phase, 60 cycle, 900 r. p. m. induction motor	66.0	77.0	82.5

High speed motors, as a general rule, have higher power factors than motors with moderate and low speeds.

Generally the question of power factor is not brought forcibly to the attention of the electrical engineer until he tries to increase the load on a generator which is running in an overheated condition although the power used is not equal to the full rating of the generator. Under such conditions, the problem presented is to make available the generator capacity which has been rendered useless by wattless current or low power factor of the distribution system.

Two methods for accomplishing the result desired are available, namely:

Substituting apparatus of given rating which will work at or near its rating and consequently at the highest power factor.

Provide suitable apparatus which will deliver to the distribution system the required amount of leading current to neutralize the lagging or wattless current caused by low power factors.

In considering the first method it is evident that changing motors to operate at or near full load ratings will produce beneficial results. In doing this, however, care should be taken to take into consideration the question of motor efficiency as it is possible to make the obtaining of high power factor in a system of distribution a rather expensive proceeding.

The following diagram, based on tests made by the General Electric Co., on standard 60 cycle induction motors, shows the saving per year due to gain of one per cent in efficiency, based on a current cost of 4 cents per kilowatt hour, the year period being assumed as 300 days of 8 hours each.

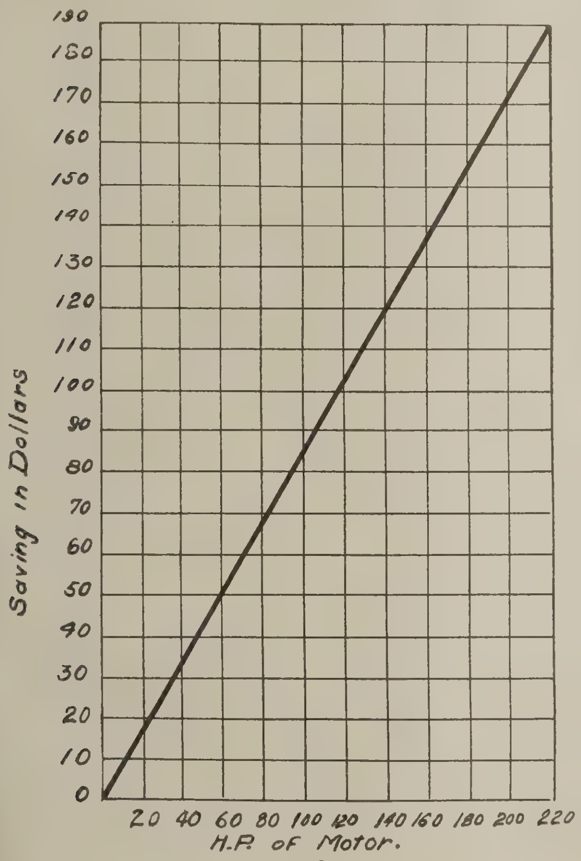


Fig. 25.

The second method of improving power factor of a distribution system is to provide a synchronous motor for furnishing the current necessary to neutralize the effect of the wattless or lagging current, the motor being required to perform a certain amount of mechanical work. It is sometimes advisable to replace a large underloaded induction motor with a synchronous motor of such size that 71 per cent of its capacity will perform the work previously done by the induction motor thus making available 71 per cent of its kilovolt-ampere rating for furnishing the leading or neutralizing current for improving the power factor of the system.

It must be remembered that the motor must be provided with a separate means of excitation and requires considerable care to obtain the desired results. Also that the load should be as uniform as possible.

A less desirable method is to operate a synchronous motor, on the system, performing no useful work and serving simply as a source of leading current or synchronous condenser. While this arrangement is effective it should be considered only where the high cost of operation and installation is warranted by the results obtained from its use.

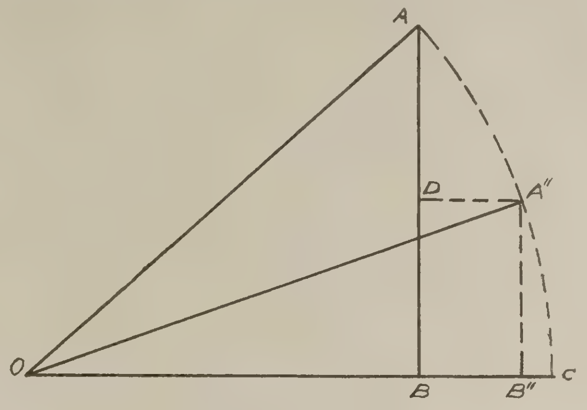


Fig. 26.

The introduction of leading current equal in value to the lagging current in Kilovolt-amperes will result in a power factor of unity or 1.

The question of how high it is desirable to increase the power factor of any system of alternating current distribution depends upon the results to be obtained and the expense of the installation.

Let OA represent the full kilovolt-ampere rating of an alternating current generator which will be assumed as operating at 71 per cent power factor. The lines OA and OC measure the angle of lag or the number of electrical degrees the current lags behind the voltage.

The angle AOC is zero when the power factor is unity.

The line AB measures the wattless component and the line OB the power component of the circuit. To raise the power factor to unity or 1 would require the introduction of a leading current equal in value to AB which would increase the generator capacity an amount represented by the line BC.

If the power factor was increased to 95 per cent instead of to unity, the angles between the lines OA″ and OC would represent the angle of lag and the lines A″B″ and OB″ the wattless and power components of the circuit respectively. To obtain the 95 per cent power factor condition would require the introduction of a leading current equal in value to the line AD and the gain in generator capacity is represented by the line BB″.

Following the above procedure it is evident that if the additional leading current represented by DB wire introduced the generator capacity would be increased by the value represented by the line B″C.

It is evident, therefore, that the nearer the unity figure is approached, the addition of a given amount of leading current increases the capacity of a generator to a lesser degree.

Numerical values show this quite clearly. In the following table is given values for power factor increase and generator capacity available by the addition of leading current necessary to increase the power factor of a system from 71 per cent to 100 per cent or unity. The amount of leading current added is given in per cents of the total amount required to produce unity power factor.

Kilovolt-amperes of leading current added in per cent of the total amount required to produce unity power factor.	Approximate resulting power factor.	Per cent of generator capacity rendered available.
0	71	0
10	77	6.1
20	83	11.5
30	87	15.8
40	91	19.5
50	94	22.5
60	95	24.8
70	98	26.8
80	99	28.0
90	99.7	28.7
100	100	29.0

The tabulation also shows that to increase the power factor above 95 per cent requires the introduction of neutralizing current out of proportion to the improvement in power factor. This being the case, it might be said in general that no effort should be made to obtain a power factor of over 95 per cent by the introduction of leading current to the system.

The Railroad Electricians' Club

The Use of Cadmium in Battery Testing

Among practical storage battery men there are usually been a certain element of mystery regarding the use of cadmium electrode in determining the potential of the battery positives and the battery negatives separately. It is the purpose of this little story to clear up some of this mystery, for it is quite a simple matter after all. On the other hand, some storage battery men swear by certain individual cadmium readings as giving an absolute indication of the battery condition and so it is also the purpose of this article to endeavor to show these latter what the limitations of cadmium readings are.

In preparing the cadmium stick for use, a stick of pure metallic cadmium is carefully sand-papered off until it is bright and clean and then a carefully covered copper wire is soldered to one end. The entire stick, and part of the connecting wire, should then be encased in a rubber tube and the end of the joint, filled with vaseline to present the acid attacking the copper wire adjoining. Small holes about as big as a pea should then be cut in the rubber tube so as to allow some of the surface of the cadmium to become exposed to the electrolyte, the purpose of the rubber tube being simply to insulate the cadmium stick from the plates of the battery when the cadmium is inserted.

It is not absolutely necessary to use cadmium—in fact any sheet of well cleaned lead or an old piece of a negative plate, which has been allowed to hang in the acid for half an hour, or so, will serve just as well as the cadmium.

When the terminal voltage of a battery fails to hold up on the capacity test discharge it may, of course, be due to a number of different causes, such as reversed cell, sulphated plates, loss of active material, etc., or it may be due to either the positive or the negative groups of the battery being sick. In the latter case it is very important to know which group is at fault and here the cadmium test comes in handy. On making the discharge capacity test, healthy negative plates should hold the potential to negative at nearly constant value of about .15 to .2 of a volt. If this shows an abnormal rise much above .25 of a volt, it indicates that the negatives are in trouble.

The potential between cadmium and positive is always greater than the terminal voltage of the cell on discharge by the amount of the potential between cadmium and negative. If this potential shows an abnormal dropping off at the end of discharge, it shows that the positives are in trouble.

A battery man should not place a great amount of confidence in any single set of cadmium readings, for there are so many things which affect these readings that unless a man is thoroughly experienced in taking them, they become practically worthless. A well experienced battery man can usually tell simply by examining the plates as to whether or not they are in good condition, with much greater reliability than he could by simply examining a set of cadmium readings. The cadmium readings are useful, if properly taken, in showing the condition of the plates but it is well for a battery man to realize the limitations and the unreliability of cadmium readings, as well as their advantages.

Temperature, as well as the gravity of the electrolyte, affects the cadmium readings, causing a higher cadmium reading with a high temperature and a strong electrolyte on discharge, than with a cold temperature and low gravity. The position of the cadmium electrode in the battery is also an important factor, but if it is placed so as to just touch the top surface of the electrolyte, the voltage readings to negative may be far different from what would be shown on the same battery if the cadmium stick is inserted well down between or at the side of the plates. With the cadmium just touching the surface, or back of either outside negative plate, the cadmium to negative readings on discharge might be uniformly low, indicating the battery in excellent condition, on the other hand, if the cadmium stick in the same cell were placed between the plates or at the edges of the elements, it might show possibly a much higher cadmium to negative reading near the end of discharge, indicating the negatives to be in trouble.

If the electrolyte is seriously stratified, that is, with heavy acid at the bottom and light acid near the top, as might be found after a charge without any gasing overcharge, the cadmium stick placed at the top of the cell would again show wrong indication in giving too low a negative reading at the end of charge, and the end of charge in this might fail to show up serious trouble in the negatives.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 45

Simplified Dick System (German)

This system of car lighting which was first described in this section in Lesson No. 24, January, 1914, issue of the RAILWAY ELECTRICAL ENGINEER, was designed by Mr. Emil Dick, Chief Engineer of the Austrian-Siemens-Schukert Works. This has been improved in many particulars so it will warrant a more complete description at this time. This system is used extensively on the railroads of Germany, Austria and Turkey and is similar in many respects to some of the American systems of car lighting.

Before describing this equipment it will be in place to tell of some of the characteristics that this equipment must have in order to serve its purpose effectively. Mr. Dick has set forth in a very logical manner the method of designing this equipment to meet the demands that will be placed upon it. Naturally the demand upon such a system will be greater while the train is in motion than at stand still and therefore there must be a voltage rise after the train has started. But this increase must be so gradual that it will not be in the nature of a flicker. Metal filament lamps are very susceptible to any change in voltage, so the maximum voltage must not be so high as to injure the lamps.

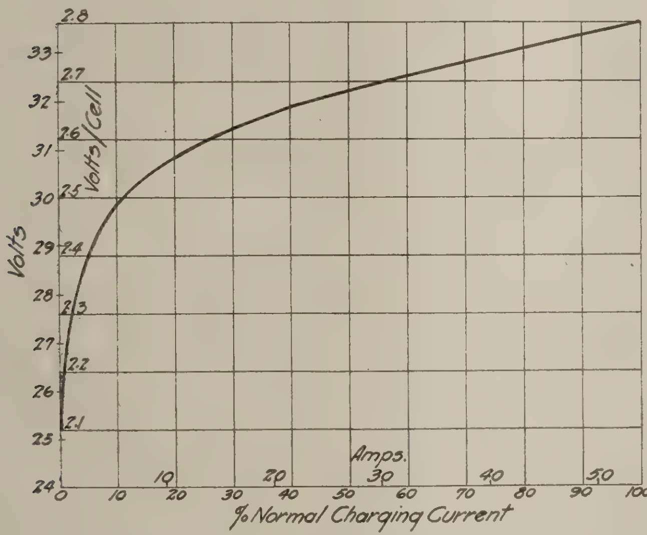


Fig. 211. Variation of the Charging Current with a Fully Charged Battery by Varying the Impressed Voltage.

Storage Battery Data.

To better understand the operation of the equipment it is well to briefly describe experiments which were made by Mr. Dick on Tudor storage batteries which had large surfaced positive plates and box negatives which were in perfect condition at the time of the test. This investigation included; the measurement of the charging current in relation to the charging voltage of the fully charged battery; the determination of the charging current in relation to the time of charging with the constant voltage; the measurement of the initial current with batteries in different states of discharge. The results of this test are shown in Fig. 211. The voltage impressed on the battery was raised every 5 minutes 0.05 volts per cell until the maximum voltage of 2.8 volts per cell was reached, whereafter the same increments were used in lowering the voltage.

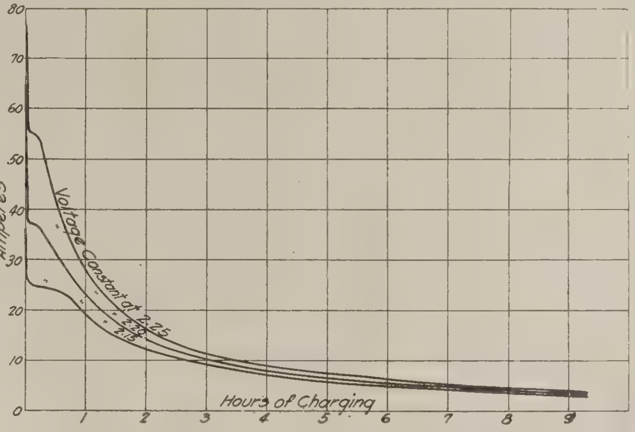


Fig. 212. Charging Current with a Constant Voltage of 2.15, 2.2, and 2.25 Volts Per Cell. The Battery was Previously Discharged at the Rate of 20 Amperes Down to 1.85 Volts Per Cell.

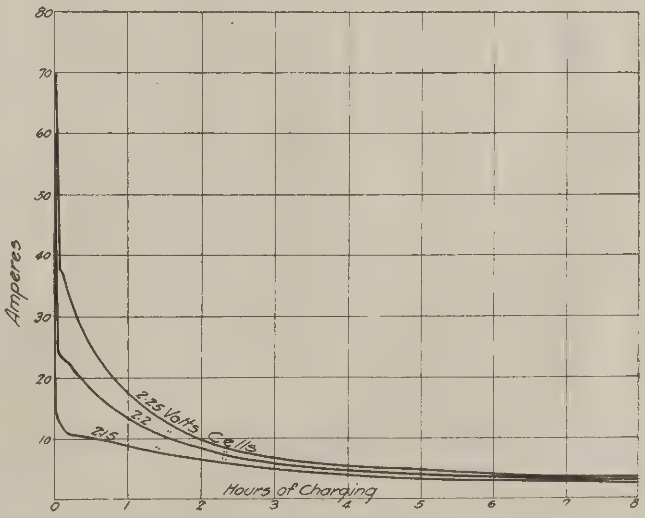


Fig. 213. Charging Current with a Constant Current of 2,15, 2.2 and 2.25 Volts Per Cell. The Battery was Previously Discharged at the Rate of 20 Amperes Down to 1.95 Volts Per Cell.

From these tests the following facts can be noted: with a fully charged battery in good condition, the current increases very slightily from 2.1 volts to 2.4 volts per cell, while from thereon the current increases steadily. The limiting voltage must not be more than 2.4 volts per cell in order to prevent a harmful overcharge. Figs. 212 and 213 show the variation of the current with the time is given with a constant charging voltage of 2.15, 2.20 and 2.25 volts per cell. The battery had previously been discharged by a current of 20 amperes down to 1.85 and 1.95 volts per cell respectively with a discharge rate of 20 amperes.

These curves are of much interest since they show how the exceedingly large initial current falls to ⅔ of its maximum value at the end of two minutes and reaches a minimum at the end of about eight hours. This shows a voltage of 2.25 volts per cell is sufficient to charge a Tudor type battery to its full ampere hour capacity, while a voltage of from 2.15 to 2.20 will only charge it to from 2/3 to 5/6 of its full capacity. The current that the car lighting generator will be called upon to supply during the instant of cutting in, under the most unfavorable conditions, will be 26 amperes lamp load and 76 amperes initial battery load, or a total of 102 amperes; and at the end of two minutes this will have been reduced to 81 amperes, as may be seen from the characteristics shown by the curves in Figs. 212 and 213.

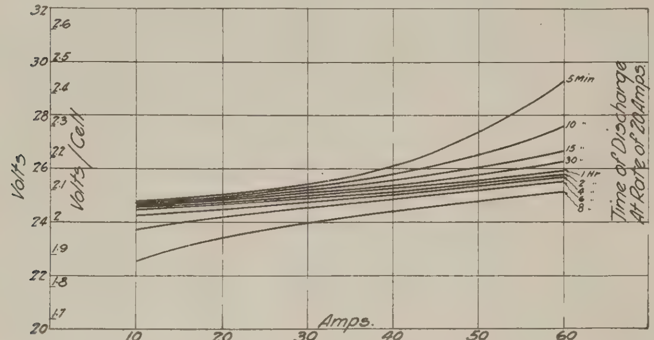


Fig. 214. Value of the Initial Rush of Current at the Beginning of Charge... With the Batteries in Different States of Discharge. All Discharges at Rate of 20 Amperes.

Fig. 213 shows that the initial current increases with the extent of the previous discharge, so after a 15 minute discharge at the rate of 20 amperes, a voltage of 2.05 volts per cell in this particular test caused 10 amperes to flow, while after an 8 hour discharge at the same rate, the same voltage will drive 45 amperes through the battery.

Method of Regulation.

In railroad service the coaches are not all regularly in use, being in the repair shop for a portion of the time and again in the railroad station supplying current to the lamps. In those cars which are temporarily out of use the battery plates are in constant danger of sulphation.

A fully charged battery will float across the line at a voltage of 2.25 volts per cell when all lamp circuits turned on but with the lamp load cut off the battery voltage increases to approximately 2.4 volts per cell. So it is evident that the regulated dynamo must exhibit some of the following characteristics. It must allow the terminal voltage to rise to about 2.4 volts per cell if the battery is fully charged and no lamps are turned on, it should, however, develop a voltage of 2.25 volts per cell, with a fully charged battery, when it is also furnishing the entire lamp load. Therefore the voltage is made dependent upon the current and if these two points (2.25 and 2.40) are plotted in a coordinate system, a line which joins these two points, shows the intermediate values of the voltage with different lamp loads.

Fig. 215 shows the working characteristics of the regulated dynamo with all lamps out. With the battery in a fully charged state the generator gives a voltage of 27 volts but with a discharged battery taking as high as 60 amperes the generator voltage is reduced to 25.2 volts. These characteristics must be independent of train speed.

To accomplish this end, the voltage is controlled by an electrically operated voltage regulator consisting of a combination shunt coil and a series coil. (The series coil can be replaced by a resistance in the dynamo circuit and the same effect will be obtained. This is not feasible, however, on account of the energy lost.) The number of turns that will be required in a series coil can be computed from the formula,

$$\text{No. turns} = \frac{NC - \dfrac{E \times N}{R}}{C}$$

Where:—

C = Dynamo current.
NC = Constant number of ampere turns of the regulator.
E = Terminal voltage of the generator delivering full current to Fig. 215.
N = Number of turns in the voltage coil of the regulator.
R = Total resistance of the regulator circuit in ohms.

When the generator current sinks to zero the limiting voltage of E′ equals $R \times \frac{NC}{N}$ volts. As shown in Fig. 215, the curent J_D equals 60 amperes and the voltage E_D equals 25.2 volts.

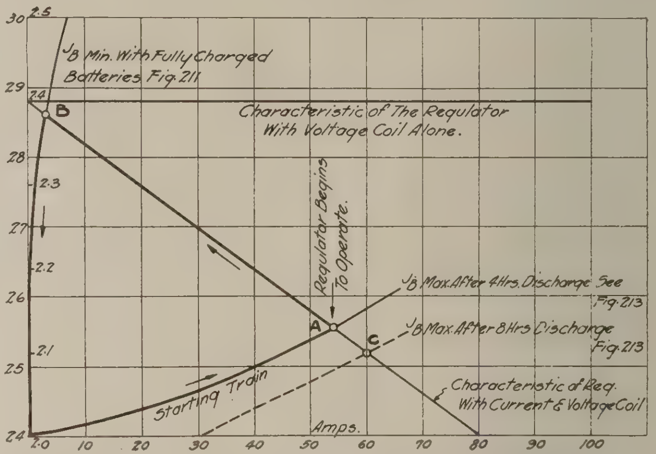


Fig. 215. Charging Diagram and Regulator Characteristic With no Lamp Load. "JB" Indicates Battery Current.

The total constant ampere turns for this regulator amount to:

NC = 1440
N = 2000 turns,
E′ = 12 x = 28.8, thus

$$R = 28.8 \times \frac{2000}{} = 40 \text{ ohms,}$$

$$\text{wherewith No. turns} = \frac{1440 - \dfrac{25.2 \times 2000}{40}}{60} = 3.$$

That is, the regulator will have 3 series turns. The line B. C., Fig. 215, makes the generator voltage dependent upon the load. The point "C" indicates the point at which the largest charging current is given out with no lamp load and is determined by the intersection of the lowest initial current curve, Fig. 214, while the point of intersection "A," Fig. 215, is determined by the maximum initial current for a fully charged battery that has previously been discharged at the rate of 20 amperes down to 1.95 volts per cell, as shown in Fig. 213. With a battery in this condition the charging current will increase with the accelerating train up to the point "A," Fig. 215, and with a further increase in the train speed the regulator comes into action and controls the voltage as indicated by the line "BC," Fig. 215. The results experimentally obtained showing current and voltage in charge are given in Figs. 216 and 217. When the battery is fully charged the voltage reaches the point "B," which is the intersection of the current-voltage curve shown in Fig. 211 with the regulator characteristic line "AB."

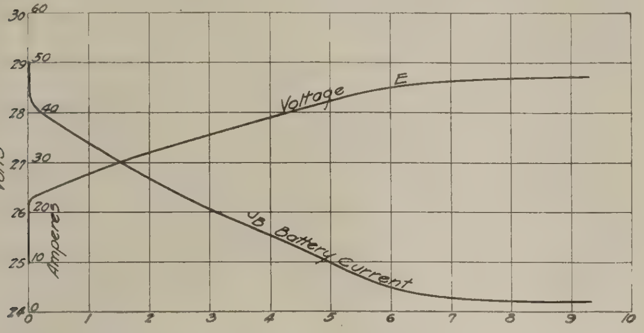


Fig. 216. Battery Charge with Lamps Turned Out From Fig. 215. The Battery was Previously Discharged at the Rate of 20 Amperes Down to 1.95 Volts Per Cell.

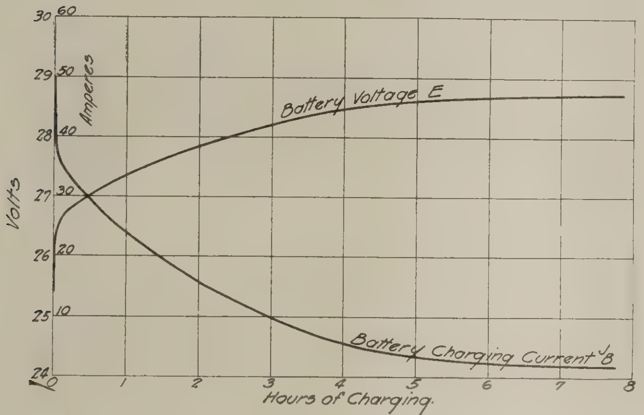


Fig. 217. Same as Fig. 216 Except That the Battery Had Previously Been Discharged at the Rate of 20 Amperes Down to 1.95 Volts Per Cell.

Effect of Voltage Variation on Lamps.

The question may arise whether such regulation is suitable for metal filament lamps, considering the voltage variation. A study of Fig. 218 will aid in clearing up this point. This again shows the operation of a four axle passenger coach outfit and is the same as Fig. 215, with the addition of the lamp current curves. With all lights on the entire lamp current J_1 is 26½ amperes at 26½ volts. $J_1 \frac{1}{2}$ indicates the lamp current with but half the lights turned on and to this the corresponding battery charging current added, so that points of intersection "E" and "F" are obtained showing the value of the voltage with total lamp load and half lamp load when the battery is fully charged. The points "C" and "D" are likewise determined by the addition of the initial battery current to the lamp current.

Operation of the Regulator.

As the train starts up, the generator current follows along the line of the initial current curve up to the point "D," when the regulator starts to operate. The generator current then decreases gradually with the increasing voltage until it reaches its minimum in point "F," with half lights on.

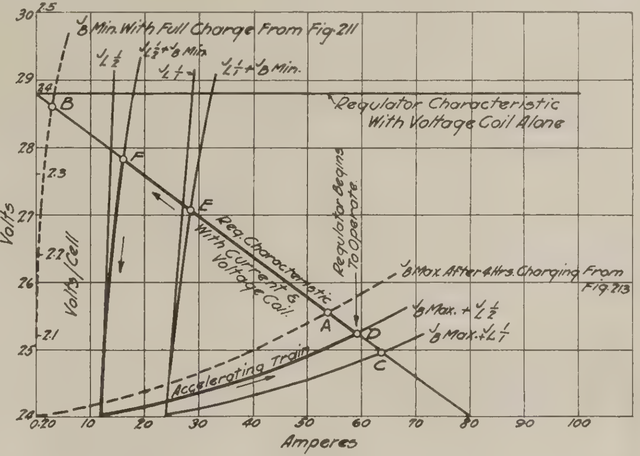


Fig. 218. Regulator Characteristic Showing Variation of Voltage and Current While the Train Passes From Rest to Full Speed and With the Lamps Turned On.

The variation in voltage and current of the generator, battery and lamps over a complete cycle of battery charge is shown in Figs. 219 and 220. These do not conform to actual working conditions, however, in that trains are not usually kept in continuous operation for 7 to 12 hours.

The total voltage variation is from 24 to 26 vlts or about 10%. This would not be admissible if it took place suddenly, but Mr. Dick shows that the train cannot accelerate rapidly enough to make the voltage increase

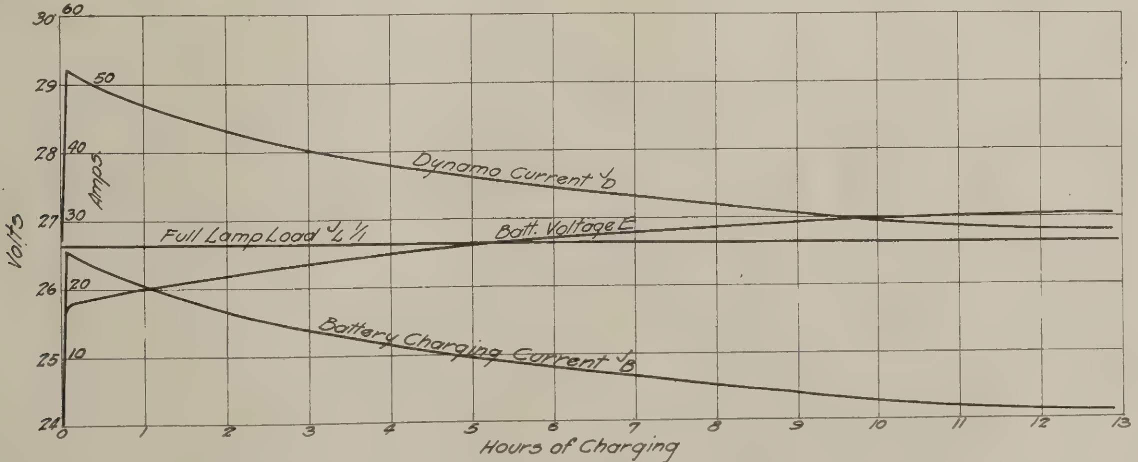


Fig. 219. Variation of Battery Voltage and Current With All Lamps Turned on as Shown in Fig. 218. Battery Had Previously Been Discharged at the Rate of 20 Amperes Down to 1.85 Volts Per Cell.

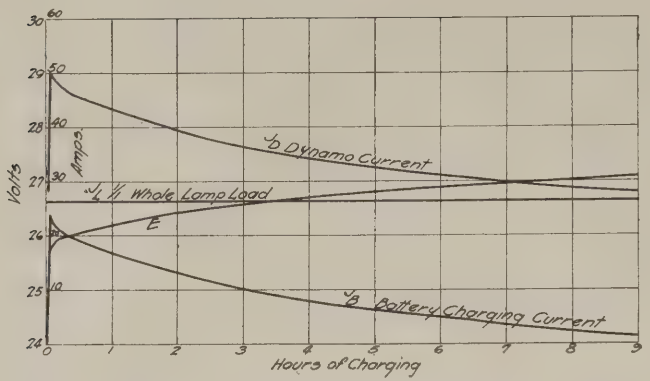


Fig. 220. Same as Fig. 219, Except that Battery Had Previously Been Discharged at the Rate of 20 Amperes Down to 1.95 Volts Per Cell.

noticeable on the lamps, the greatest voltage increase that could take place in any one second being not more than 0.3% per second. In Fig. 221 the relation of the lamp candle power to the voltage is shown.

A glance at Fig. 219 and 220 shows that there is no great voltage change after the starting period. As may be seen from Fig. 218, the voltage may reach a value of 27.6 volts at half lamp load and with fully charged batteries. For this reason it has been found that a better lamp life is obtained if the lamps are designed for a voltage of 26½ and for a power consumption of 1.1 watts per candle. Although with a fully charged battery with only one or two lights burning, the voltage may become even higher than this, the fact still remains that this excessive voltage generally is impressed across the same few lamps. If these lamps are made for a higher voltage, this difficulty would be largely overcome.

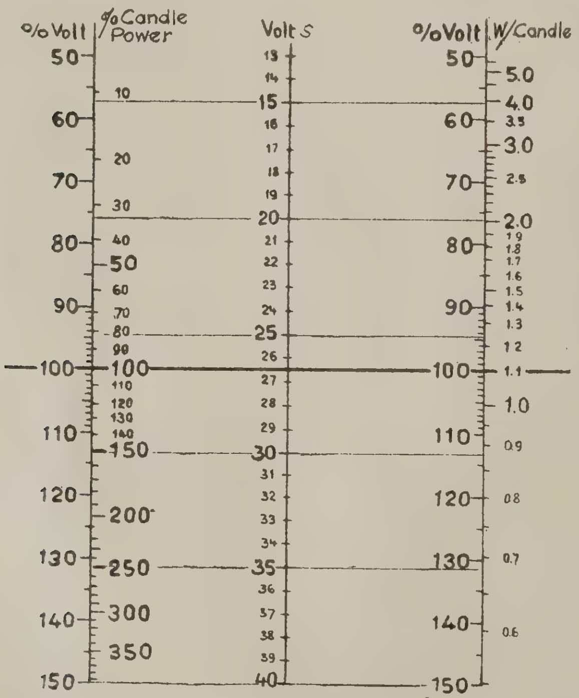


Fig. 221. The Variation of the Candlepower and Power Consumption With Voltage For Wotan Lamps, 100% is Taken as 1.1 Watt Per Candle.

Description of the System

Generator.

The generating unit of the system is a four pole shunt wound dynamo which is either placed on the trucks or hung from the car body. It is entirely enclosed and the shell is made of cast steel. The armature is of the drum series wound type, the field coils being impregnated with an insulating lacquer. The pole changes consist simply in the brush rigging being movable about the shaft of the dynamo, the brushes being shifted through an angle of 90 deg. by the brush friction on reversal of direction of car motion. The travel of the brush rigging is limited by two striking posts so that the point of commutation is always correct and the correct polarity of the generator maintained.

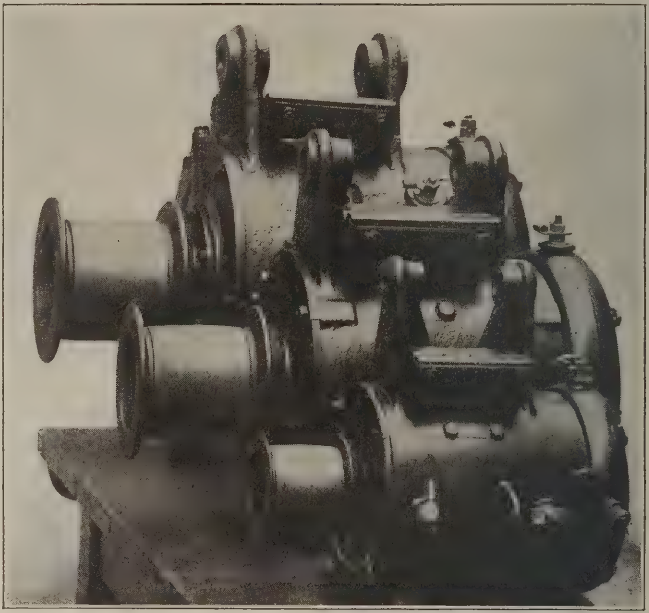


Fig. 222. Car Lighting Generators for Two Axle, Three Axle and Four Axle Passenger Coaches, Types ABL, KBL and AL.

The generator is equipped with ball bearings because of the small amount of attention which they require. All screws and nuts are protected from being shaken loose by the vibration by jam nuts and lock washers. The dynamo is self excited and therefore is independent of the voltage of the storage battery.

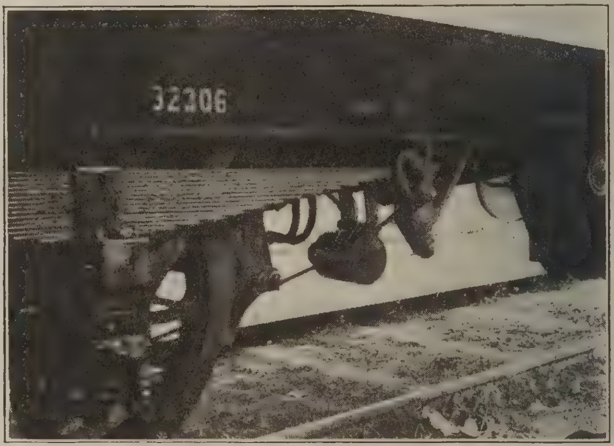


Fig. 223. Body Hung Suspension of a Type AL Generator on a Two Axle Passenger Coach.

The machines are made in 4 sizes, as shown in Fig. 222.

Type A. L. for small 2 axle passenger coaches, 200 watts capacity.

Type K. B. L. for larger 2 axle and 3 axle passenger coaches, 400 watts capacity.

Type A. B. L. for 4 axle passenger coaches, 800 watts capacity.

Type C. L. for 4 axle and 6 axle passenger coaches, 1.1 kw. capacity.

Figures 222 and 223 show the three smaller sizes of car lighting generators, the weights of the generators being 66 lbs., 165 lbs. and 285 lbs., respectively.

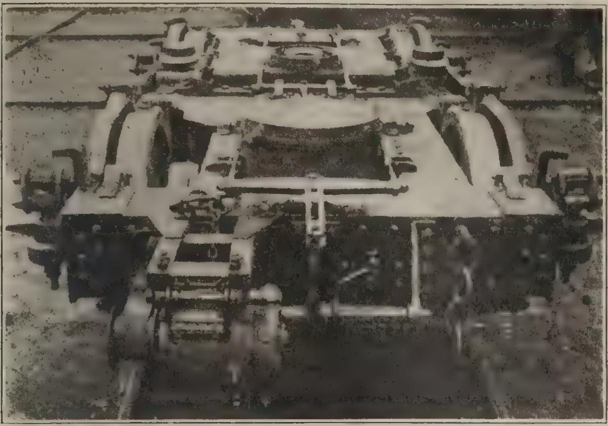


Fig. 224. Truck Suspension of a Type AL Generator.

Generator Suspension.

A diagramatic sketch of the body hung type of suspension is given in Fig. 225. It is recommended that the driving pulley be mounted as near one wheel as possible in order to make it easier to apply the best. The manufacturer states that inasmuch as a long belt has a longer life, the body hung type of suspension is preferred to the practice of mounting the generator on the truck. Fig. 224 shows a truck mounted generator and Fig. 223 shows the body hung suspension on a 4 wheel coach. In order to make the replacement of defective belts easier, the belt length for each type of machine is made the same so that the belt can be cut and applied without measurement.

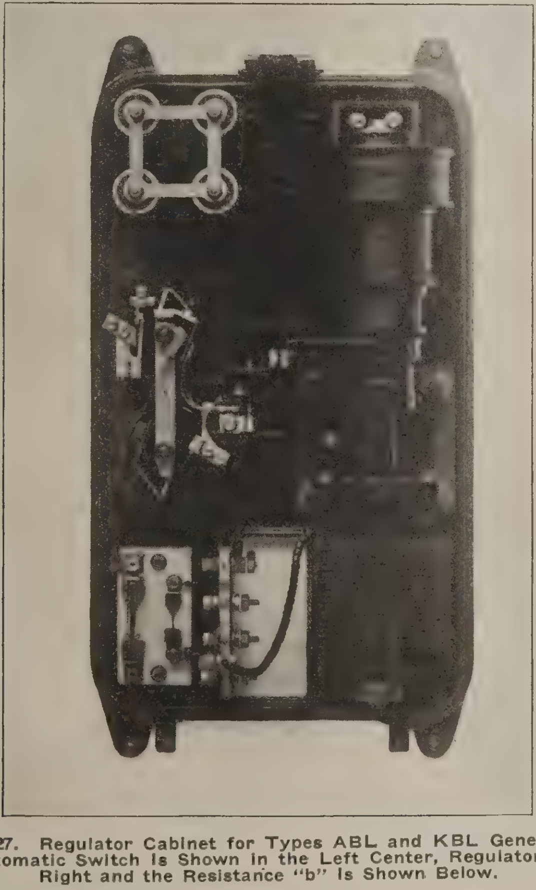


Fig. 227. Regulator Cabinet for Types ABL and KBL Generators. Automatic Switch Is Shown in the Left Center, Regulator at Right and the Resistance "b" Is Shown Below.

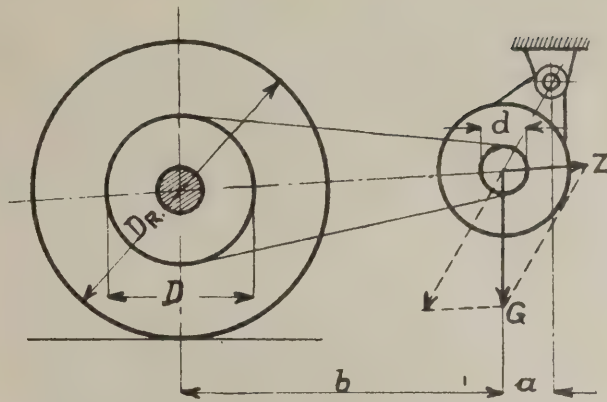


Fig. 225. Drive of a Body Hung Car Lighting Generator.

Generator Regulator.

The generator regulator consists, as in most constant voltage systems, of a voltage coil which by means of a core plunger reduces the field excitation and tends to keep the voltage constant. Fig. 226 gives a diagramatical sketch of the regulator used with this equipment. The voltage coil "A" made up of a large number of turns of

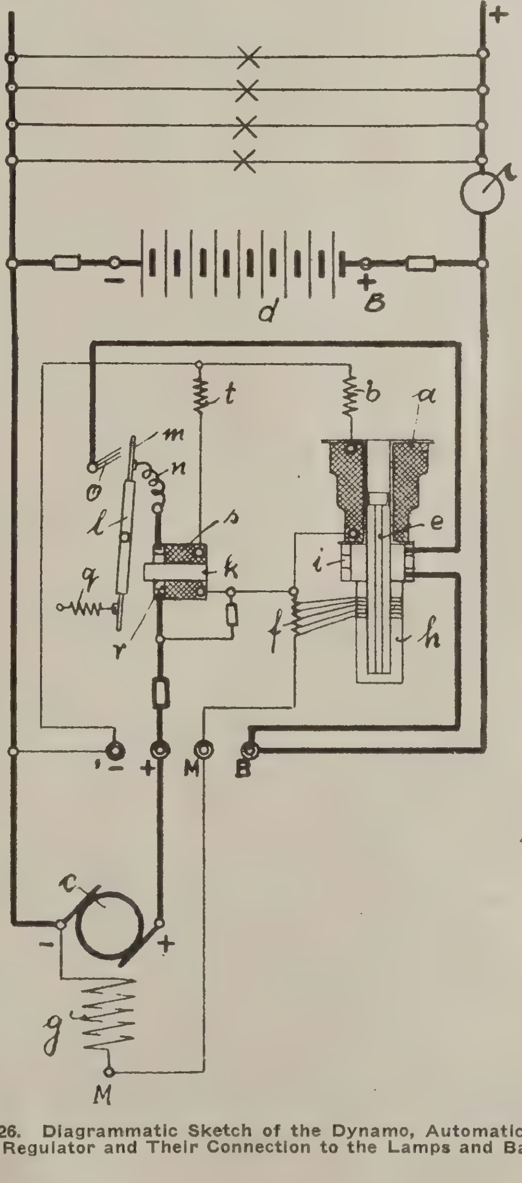


Fig. 226. Diagrammatic Sketch of the Dynamo, Automatic Switch and Regulator and Their Connection to the Lamps and Battery.

fine wire and is tapered so that the coil increases in breadth toward the top. This is connected in series with a resistance "B" across the terminals of the generator "C." The adjustable resistance "B" serves first to quickly adjust the terminal voltage to 28.8 volts (2.4 times 12) for a 12 cell battery. It also serves to compensate for the heating of the coil. An iron plunger "E" is enclosed inside of this coil and is guided by a brass tube. The plunger is electro magnetically operated by the coil "A" and regulates the resistance "F," which is in series with the field coils "G" of the generator. This completes a second shunt circuit to the dynamo.

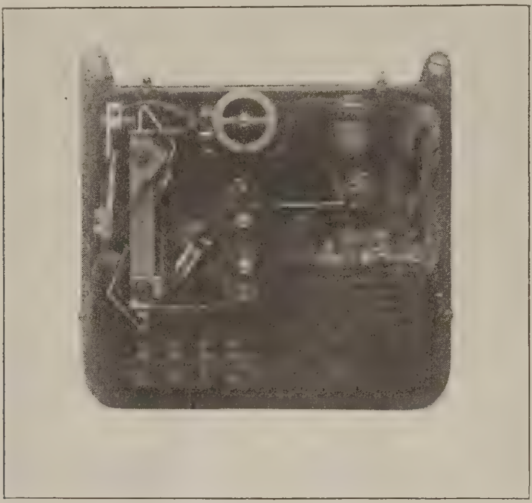


Fig. 228. Regulator Case for the Small Type AL Generator.

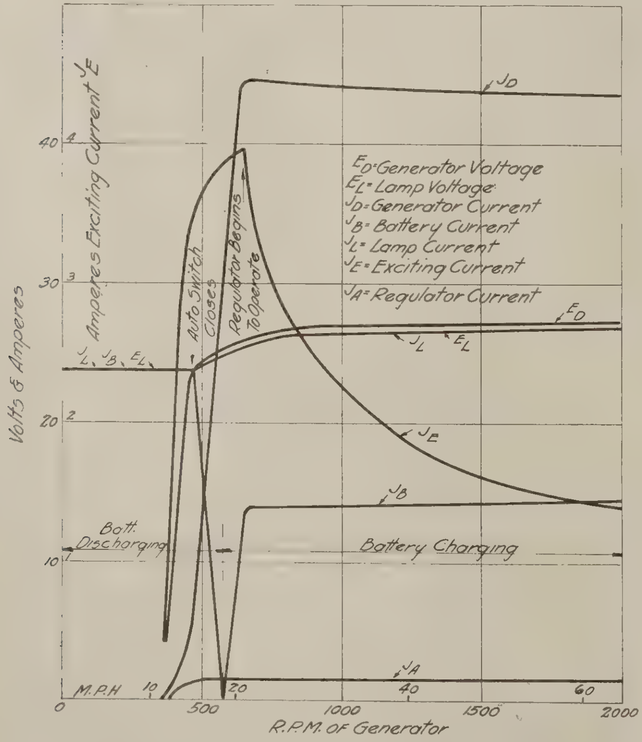


Fig. 229. Variation of the Current and Voltage in Different Parts of the System, While the Train Is Traveling at Different Rates of Speed, All Lamps Turned On.

The field resistance is regulated on the circumference of the mercury chamber "H" and its operation is as follows: The upper part of the chamber "H" is made up of metallic rings which are separated from one another by an insulating material, the whole being bolted together so as to be rigid. The rings are electrically connected to segments of the resistance "F." The plunger "E" normally rests on the bottom of the mercury chamber at which time the mercury from the bottom of the chamber is forced upward, short circuiting all the resistance contacts, but when the plunger is attracted by the solenoid and is raised, the mercury sinks in its chamber and cuts in the resistance one step at a time. This chamber is well ventilated so that any heating which may occur will not injure the apparatus.

The terminal voltage of the machine is maintained at approximately 28.8 volts by means of this regulator so the forces which act on the plunger must be in equilibrium at every moment. Acting downward is the weight of the plunger "G," opposing this, the forces which tend to raise the plunger, viz., the buoyancy of the mercury "Q" and the magnetic pull of the solenoid "Z," so the equation "G" minus "Q" equals "Z." In order to prevent hunting action and to damp out any sudden change, the piston of the plunger fits tight enough in the solenoid so as to act as a dash pot plunger.

Joint Meeing of the Railroad and Industrial Commission of Wisconsin.

On October 22nd a joint meeting of the railroad and industrial commissions of Wisconsin was held in the assembly chamber of the state capitol. This was a public hearing and representatives of public service utilities, railroad electrical departments and telephone interests were present. Tentative standards for electrical construction and operation had been drawn up. A large part of the discussion devoted to ways of preventing interference between public utilities, especially as applied to the interference of high voltage transmission lines with telephone and telegraph lines.

The tentative rules which were drawn up were essentially those adopted by the railroad commission of the state of California through its joint committee on inductive interference. The two commissions will attempt to draw up the rules so that future interference will be avoided and to prevent means for the simplest settlement of disputes over present installations. In case of disputes the rules provide that the commission shall be the arbiter.

To insure safety to operators and other persons coming in contact with electrical installations, a set of tentative rules were also adopted, which are something similar to those being drawn up by the Bureau of Standards. These safety specifications will apply to nearly all lines of electrical installations and when completed should be a great help in insuring that future installations shall be safe.

The Largest Central Station Battery in the World.

The Detroit Edison Co. of Detroit, Mich., has contracted for the building and erection of a new Central Station Storage Battery, which will make it the largest in electrical output ever built for emergency use.

The battery will consist of 150 cells, each containing 169 plates of Type H "Exide".

Each of the 150 lead lined tanks will measure 6 ft. 7⅝ in. in length, 21¾ in. in width and 4 ft. 2 in. in height. Each cell complete with plates and electrolyte will weigh 7,700 lbs.

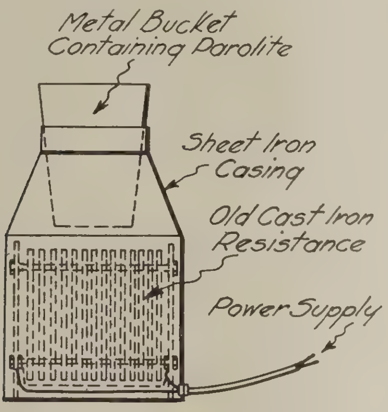
The capacity of the complete battery will be 12,600 amperes for one hour, or 26,040 at the 20 minute emergency rating. In connection with the operation of this large battery, The Electric Storage Battery Co. will build four 7-point 10,000 ampere motor driven end cell switches, two of these to be placed on each side of the three-wire system.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Heating Parolyte by Electrictiy.

In large terminals where electric power is available, the use of a discarded cast-iron grid resistance may be found very handy for making a parolyte heater. The accompanying sketch shows a home-made heater which has given very good satisfaction. A sheet iron casing is made which is large enough to enclose the resistance units and with an opening at the top large enough to hold a basket. This furnishes a ready means of keeping the parolyte hot. The circuit to the heater is controlled by a switch, enabling the operator to use his pot whenever he desires. Its great convenience lies in the fact that it requires no attention and is always ready for operation.



Old Grid Resistance Used for Heating Parolytle.

J. E. Snyder, Crafton, Pa.

Removing Fan Brushes That Stick.

Difficulty is sometimes experienced in removing fan brushes when they stick. A good way to remove them is to get a corset stave about ¼ in. wide and bend one end to make a small hook. With the use of this instrument the brush can be pulled out. I am enclosing a small sketch for an illustration.

W. C. Burgess,
A. T. & S. F. Coach Yards, Los Angeles, Calif.

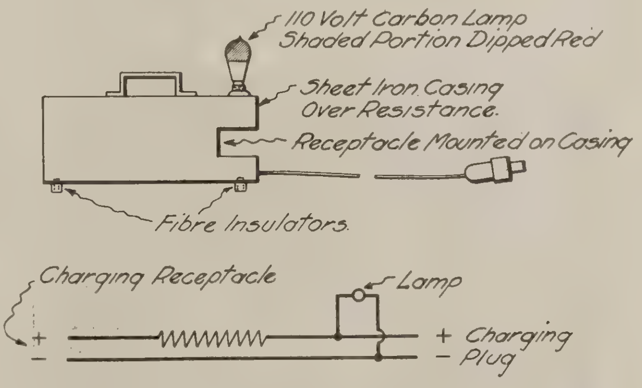
A Specific Gravity Tester.

This specific gravity tester was designed by the writer, as described in the following paragraph. It consists simply of a hard glass tube of a uniform diameter, which acts as a plunger inside of a hard rubber tube. This outer tube is about 1¼ in. in diameter and 9½ in. long and completely covers the glass tube when the apparatus is closed up. A flange on the top edge of the glass tube prevents it from being pulled out through the bottom gasket. This gasket at the bottom is of soft rubber, and fits very tight to the surface of the glass, so as not to leak air. A cap screw with a small air hole in the center seals the top end of the hard rubber tube, and this being provided with a small rubber washer makes the chamber air tight.

A hydrometer is placed in the glass tube, and this is protected by rubber washers at the bottom of the glass tube, and also on the inside of the cap, to prevent the hydrometer being broken. To take a reading it is only necessary to insert the rubber tubing into the cell and pull the glass tube out of the ebonite tube, meanwhile keeping the air hole in the cap screw closed with your thumb or finger. This will draw the electrolyte up into the glass tube containing the hydrometer and a reading can then be taken. To discharge the electrolyte further, simply remove your thumb from the air hole and let it run out, or by keeping the air closed force down on the ebonite tube forcing the electrolyte back into the battery.

Charging 30-Volt Cars From 60-Volt Circuits.

In yards wired for 60-volt charging, it is frequently necessary to charge 30-volt cars by means of a portable resistance. At night these units are in the way and the operator must hunt for them and test them to see if the current is on. To remove this difficulty, a carbon lamp can be connected across the terminals so soon as that circuit is plugged in, the lamp will light up when the plug is put in the receptacle along the walk. The accompanying sketch shows the resistance unit and its connections. The car is then put on charge by connecting the yard cable to the receptacle on the resistance and connecting the cable from the resistance unit to the car. At night, with the lamp burning, it is clearly visible, especially with the top of the globe painted red. This also indicated a blown fuse or other trouble in the charging circuit.



Handy Resistance for Charging 30-Volt Battery From 60-Volt Line.

J. E. Snyder, Crafton, Pa.

Dynamos That Throw Oil.

Bliss dynamos often give some trouble by throwing oil and this may be remedied as is described below:

1. Where an armature has more than ⅛ in. end play, apply fibre washers on commutator end to reduce the play to 1/16 in.
2. Where the pulley bore is so large that the pulley fits close to dynamo bearing, apply thin tin shim on pulley seat, so that pulley cannot touch bearing.

W. C. Burgess,
A. T. & S. F. Coach Yards, Los Angeles, Calif

Convenient Drill Rack.

In order to keep our small drills and those which are used most frequently in good order near the drill press, we constructed a special rack for holding them. A line of holes was drilled in one edge of a piece of maple, so as to hold all sizes from 1/16″ to ¾″. This was fastened to the solid part of the drill press. This rack holds the drills in a single line in an upright position where they are freely accessible.

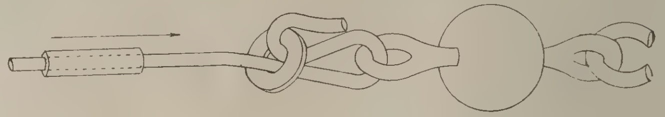
To tell the size of a drill at a glance fasten a strip of brass at the front of the rack and either stamp on it or paste a piece of paper which states the size of the drill which is in the hole opposite it.

C. B. Jennings, Topeka, Kans.

Simple Scheme for Dead-Ending a Crane Trolley Wire.

The accompanying illustration shows a convenient and serviceable way of dead-ending a traveling-crane trolley wire, such as employed in railway shops. For a No. 2/0 copper wire a ½ inch punched wrought-iron bolt washer may be used, and for other sizes reference to a wire table will show the size of washer required to fit over twice the diameter of the wire used.

And another striking feature is the fiber tube as shown below the arrow, is used as a safety stop. The tube is about 20 inches long and is set about 30 inches from that washer. In case of accident the tube lifts the trolley from the wire and the traveling crane stops.



To start the crane again, the tube is shifted towards the washer. The crane is then started and later the tubes are reset on the original position to be ready for the next emergency. This scheme, I presume, was originated in C. P. R. Angus shops at Montreal, Quebec., and it works quite satisfactory.

J. G. Koppel, S. Ste. Marie, Mich.

With the Manufacturers

E. W. Jansen

At the close of the Eighth Annual Convention of the Association of Railway Electrical Engineers, Mr. E. W. Jansen, electrical engineer Ill. Cent. Ry. and formerly vice-president of the Association, was elected president to serve for the ensuing year. Mr. Jansen was born in Quincy, Ill., July 20th, 1874. After completing a course at the Quincy High School he entered the employ of the Quincy Electric Railway in July, 1891. He remained with that institution in the capacity of assistant to the electrician until May, 1892, on which date he accepted a position with the Cornish Electric Company of Chicago, as foreman in charge of wiring for lighting and motor boat installations in the Chicago district.

E. W. Jansen.

In June, 1894, he severed his connections with the Cornish Electric Co., to become associated with the Waddell-Entz Co. of Chicago, being employed on the installation of electrical equipments. In January of the following year he accepted a position with the Great Northern Hotel Company during the construction of their building.

He left the employ of this company to accept a position with the Illinois Central Railroad as electrician on their 12th street direct current plant. In 1900, when the Illinois Central installed a terminal plant at 27th street, supplying a 6,600 volt three-phase current to all stations, buildings and yards from 91st street to the Chicago river, he was appointed in charge of all the electrical work connected therewith. In November, 1904, the position of chief electrician was created on the Illinois Central system, to which he was assigned, having charge of construction and maintenance of electrical work on the system, with the exception of maintenance of electrically lighted cars and electrical matters at the main Burnside shops. On April 1st, 1910, he was appointed electrical engineer of the entire Illinois Central system, which position he now holds.

Mr. Jansen's ability and forcefulness, which are so well known to his many friends in the railroad field, will undoubtedly give a good account of themselves in a successful year of accomplishment for the Association.

Mr. T. Lee Miller has been placed in charge of the Sangamo Electric Company's New York Office, 50 Church St. He was graduated from the University of Cornell, Class of 1909, with the degree of Mechanical Engineer, and established connections with Marwick, Mitchell, Peat & Company, accountants, where he originated and established the present efficiency system for the Buick Motor Company. For the past four and a half years he was associated with the Toledo Railways & Light Company in the capacity of Assistant to the President in charge of Purchases and Car Maintenance. Mr. Miller is an associate member of American Institute of Electrical Engineers and of the American Society of Mechanical Engineers. He is a member of the National Electric Light Association, Racquet and Tennis Club, Cornell University Club, and West Side Tennis Club of New York.

U. S. L. Notes.

The U. S. Light & Heat Corporation has established a Kansas City branch with offices at 607 O'Rear-Leslie Bldg. Complete data and information can be obtained there regarding all of the company's products. Mr. W. W. Pennington, formerly of the Rock Island Lines and recently connected with the Chicago branch of the U. S. L. & H. Corp., has been appointed manager.

Portable Current Testing Outfit.

There are many uses in central station work for a high grade portable current testing outfit that combines accuracy and lightness with low first cost. Such an outfit with a capacity of 75 to 250 amperes is now offered by the Westinghouse Electric & Mfg. Co. The transformer is so constructed that it can be clamped around any cable or feeder without opening the circuit, and therefore has a wide field of usefulness in testing cables in the power house, in manholes, or on the line.

The standard outfit consists of a portable split-type current transformer, a type PR portable ammeter, a set of leads 10 feet long and a leather carrying strap. The total weight of the outfit is less than 30 pounds.

The split-type current transformer is made with a clamp at one end and a hinged joint at the other, so that the two halves can be opened up, slipped over the cable, and clamped together tightly. The use of this transformer obviates the necessity of opening the main circuit to make a test. By means of binding posts on the transformer, connections can be made for obtaining full scale readings of either 125 or 250 amperes.

Improved Industrial Type Oil Switch.

This improved type of oil switch is used extensively in industrial establishments to control and protect induction motors up to 2,500 volts and 300 amperes. It can be mounted on a wall, post or other vertical flat surface, or by means of suitable supports on the machine operated by the motor. The switch is made by the General Electric Company in both non-automatic and automatic forms; the first simply to start and stop the motor, and the second to cut off current from the motor automatically on the occurrence of an overload greater than that for which the overload trip is set.

Through a recent improvement in the design of the mechanism, a low-voltage trip can be added to the automatic switch as an attachment at any time. To the non-automatic switch, either a low-voltage trip or a series-overload trip, or both, can be added whenever desired. Both means of tripping are mounted inside the switch cover.

Up to 550 volts (except on 110 volt, 60 cycle circuits, where the trip coil only is sufficient) an auto-transformer is used in place of the resistance previously required in series with the low voltage tripping coil. This transformer has taps to which proper connections can be made for the operating voltage. For 2,200 volt circuits, a new type voltage transformer replaces the transformer and series resistance used heretofore. The use of the new auto-transformer, or voltage transformer, makes the watt loss in the low-voltage device practically negligible.

On the switch with the time limit overload trip, the calibrating tubes and dash pots are protected from injury by a cast iron guard which has been added to the equipment.

Switches can also be furnished with covers arranged to mount a round pattern ammeter and provide, in addition to control and protection, a means of knowing at all times the amount of current being taken by the motor. This gives a continual indication of the motor load and the opportunity to detect trouble in the motor or its circuit.

Rural Substations in Railway Signal Work.

The field of application of the rural substation is constantly broadening as its merits become better recognized. The main features are, of course, mobility, ease of installation and low initial cost as compared with a permanent indoor substation of like capacity to accomplish the same result. These points often exert a weighty influence on the solution of the problem of electricity supply, especially when the probable revenue is somewhat speculative, or the need for power either temporary or seasonal. In other cases the question of cost does not determine the installation itself, but merely its character. The accompanying illustrations show views of the first outdoor type steel switch houses of this class built for railway signal purposes, and are used in this connection by the Southern Railway at Inman, S. C., and Austell, Ga. The outdoor substations, of which the switch houses are a part, effect a considerable saving in outlay as compared with what would have been the cost of a substantial permanent substation to house the equipment. Each house is located at the foot of a pole tower supporting the transmission line, the outdoor power transformers, disconnecting switches, choke coils and lightning arresters.

The equipment of the switch houses is a little more elaborate than usually required for power or lighting purposes. The ordinary house, such as exhibited at the Railway Appliance Association Exhibition last month, has merely an oil switch. or an oil switch and watthour meter, with the necessary current and potential transformers. In the house illustrated, there are also an extra potential transformer, a voltmeter, a circuit closing relay, two potential receptacles, and an incandescent lamp with bracket. The extra transformer, two potential receptacles and voltmeter in connection with the other two potential transformers required for the watthour meter, allow the voltage to be read on both sides of the oil switch before it is closed. The incandescent lamp gives illumination at night for reading the voltage or for lighting the inside of the house.

Equipments of this kind are now being built by the General Electric Company. The houses are shipped wired complete, so that the only construction work necessary to put them in commission is to place oil in the oil vessels and connect the incoming and outgoing leads to the roof bushings.

New Body Hung Suspension.

The axle type of generator suspension has often been criticised on the ground of being inaccessible and of having too many wearing parts to get loose. This has led to the development of several types of body hung suspensions. The advantage of these equipments is that they reduce the unsprung weight on the trucks as well as reducing the total weight of the suspension. These body hung types have also made the generator more accessible, which is a point that is appreciated by the repair man.

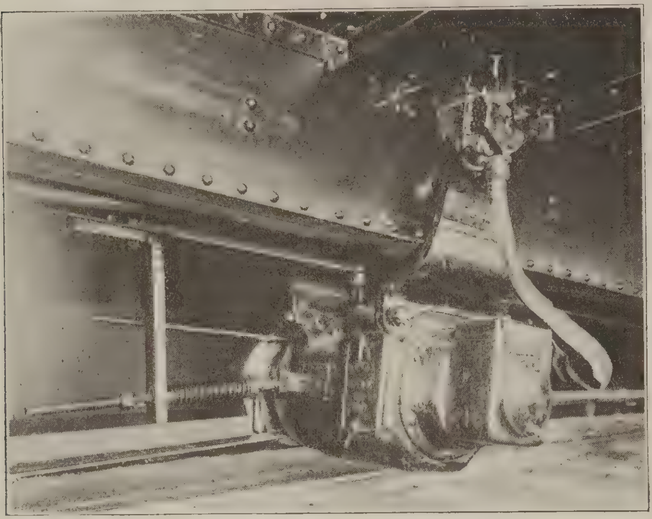


Fig. 1. New Body Hung Suspension Showing Belt Tightening Spring.

The Illinois Central Railroad have just built an ex-experimental suspension that seems to answer all objections to this type of equipment. Fig. 1 shows this suspension mounted on the fish-belly girders of a new steel coach. By removing the belt, the repair man is able to move about on all sides of the generator.

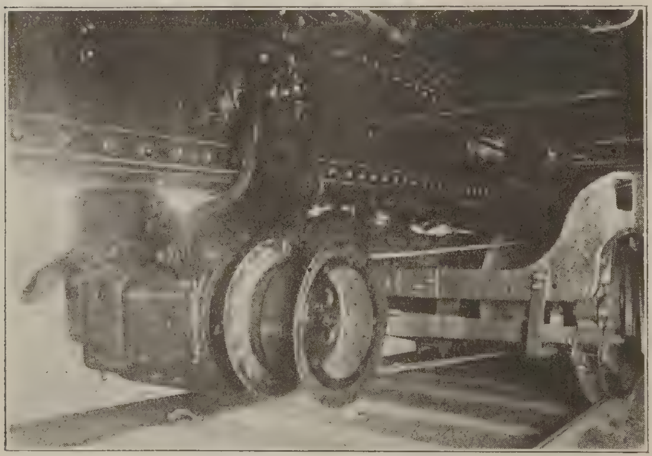


Fig. 2. Notice Safety Chains Securing Generator to Girder.

The mechanical details of this suspension are very simple. Two hubs, shown in Figs. 1 and 2, are fastened onto the fish-belly girders and a pipe runs between them, for the shaft to turn in. The 2¼-in shaft is placed in this pipe so the only point for wear is the shaft in the pipe. To insure that these points are well lubricated at all times, a grease cup is placed on the pipe, surrounding the shaft, so that bearing is greased from this one source. The suspension arms are bolted to the base of the generator and are keyed to the bearing shaft and secured with cotter pins, making the whole suspension integral and rigid. As a matter of safety, the generator is also fastened to the girders by means of two one link, 1-in., safety chains that would prevent the generator from falling onto the track if the main suspension should break. A brace is bolted to the fish-belly girders for the tension spring to work against. This is shown in the two views of the suspension.

Westinghouse Awards.

The Westinghouse Electric & Mfg. Company announces the following more important among the large number of awards received at the Panama-Pacific International Exposition.

The Grand Prize, the highest possible award, on the 4000 h. p., 650-volt, d. c. double-unit Pennsylvania electric locomotive mounted on a turntable under the dome of the Transportation Palace. The Medal of Honor on alternating current and direct current industrial motors and control apparatus, on precision instruments, on Le Blanc condensers, on motor-generator sets for moving picture machines and on high voltage oil switches. The Gold Medal on a number of different classes of apparatus among which are steam turbines, alternating and direct current generators, alternating current and direct current railway motors, transformers, rectifiers, starting, lighting and ignition systems, switchboards and accessories, and mining locomotives.

A number of silver medals and bronze medals were also received.

The Westinghouse Electric & Mfg. Company was also awarded the Gold Medal for the most complete and attractive installation in the Palace of Transportation.

Text Books on Alternating Current.

Prof. F. E. Austin has recently issued a second edition of his book entitled, "How to Make Low Pressure Transformers". In the 17 pages contained in this book directions are given for constructing and designing a transformer for low tension work. The separate steps in both the construction and design are very clearly set forth and this should prove of interest to students and experimenters who are interested in this subject. The price of this book is 40c.

Another book recently published by Prof. Austin is entitled, "Examples in Alternating Currents for Students and Engineers". The book has flexible binding and contains 223 pages of reading matter, which is printed in green ink, probably for the purpose of making it easy to read. In treating this subject, some of the more usual trigonometric formulas are developed and problems in calculus are also given, which are used in the solution of alternating current problems. Both of these books may be had of Prof. Austin, of Hanover, N. H.

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Which System for Electrification?

This has been the eternal bone of contention with railroad electrification engineers since the development of the single-phase and three-phase systems, and there is probably no doubt but with the strong convictions of eminent engineers favoring one or the other system there has been created in the minds of higher railroad officials a certain skepticism regarding the feasibility of railroad electrification. It has always been maintained in these columns that no one system had eminently superior qualifications for universal electrification, and that each condition required special consideration, as each involved special problems.

Although radical developments have been made in heavy electric traction during the past year, the fundamentals of the proposition are not essentially changed. It is interesting to note that in the presentation of the report of the Committee on Abatement of Smoke and Terminal Electrification at Chicago, a similar sentiment is expressed, in which the committee states that although they consider the single phase system best suited to Chicago conditions they do not find it advisable to recommend any one particular type of electrification for universal adoption and that even if this were done, and whatever system might be recommended, certain eminent and conscientious engineers could offer just criticism.

The developments in heavy electric traction of the last year, however, seem to point to a more extensive use of the overhead contact system in preference to the third rail. This is due to improvements in the standard single-phase system, the development of the split-phase system as employed on the Norfolk & Western, Bluefield Division, with an operating voltage of 11,000 a.c. at trolley, which is converted to essentially three-phase current by means of a phase splitter on the locomotive. The wonderful development of high voltage direct current systems as found in the 3,000 volt electrification of the C. M. & St. P. and the successful 5,000 d.c. experiment on the Michigan United Traction Lines is another strong indication that the heavy electric traction of the future will be of the overhead contact or trolley type.

In view of these great strides in both a.c. and d.c. traction which have been made in the past year, it is now even more impossible than ever before to say that any one system is superior to all others.

Smoke Abatement in Chicago By Electrification of Railway Terminals

Since 1874 and perhaps earlier there has been a growing sentiment among the people of Chicago that the steam locomotive was the chief source of the smoke which contaminated the city's atmosphere. This sentiment found expression in more than one attempt to compel the railroads to electrify within the city. Finally, realizing that a correct solution of the smoke problem could be based only on complete scientifically obtained information and data, the Association of Commerce, in 1911, organized a committee to make a thorough study of smoke abatement and electrification of railway terminals. Four of the members were named by the Mayor, nine by the Association of Commerce, and four by the railroads, who furnished the necessary funds.

The committee, with the assistance of a staff of 17 experts, has just finished what is recognized as the most comprehensive study of smoke abatement and terminal electrification ever made. An abstract of its report, which was formally presented to the president of the Association of Commerce on December 1, appears elsewhere in this number.

The outstanding facts as brought out by this report are that the complete electrification of the Chicago railroad terminals as a means of lessening smoke pollution is technically practical, but financially impractical, that "before the steam locomotive is eliminated pollution must first be reduced to a minimum from the three more damaging services, namely, high pressure steam plants, metallurgical and other manufacturing furnaces, and domestic fires" and that electrification would eliminate only five per cent of the gaseous pollution and less than four per cent of the solid pollution of Chicago's air. The number of important sources of smoke other than the locomotive as disclosed by the committee's report is a revelation and has a most important bearing on future work in connection with smoke abatement in any large city. It can no longer be said that this, that, or the other interest produces all the smoke. Each contributes its share and to effectively deal with the problem of smoke abatement each must receive attention. Another significant fact brought out by the investigation is that only two-thirds of all the dust and dirt in the city is of fuel origin, the other third resulting from the general activities of the city.

The subject of civic cleanliness, therefore, embraces more than smoke prevention or abatement, and a great deal more than the mere electrification of steam railroads within the city limits. That the committee realized this fact is clearly shown in its final recommendation as to the best method of reducing the air pollution of Chicago to a minimum. The committee suggests the creation of a permanent Pure Air Commission empowered to supervise all city activities which produce one-third of the city's dirt and to investigate and devise means of abating air pollution by railroad locomotives, steam boats, high pressure steam plants, metal foundries, etc., which produce the remaining two-thirds.

The facts as brought out by this committee demonstrate the unfairness, unreasonableness and futility of forcing railroads to electrify their terminals purely on a basis of reducing air pollution.

Inductive Interference of Single-phase Railways

In another part of this number appears a comprehensive article describing the electrified suburban division on the Pennsylvania between Philadelphia and Paoli. One of the most important features of this installation is the novel method of reducing inductive interference of the railway traction current on telephone and telegraph lines adjacent to the railway.

It will be recalled that only about a year ago a novel means was devised for accomplishing the same results on the electrified lines of the New Haven. This was described in the May, 1914, issue of the *Railway Electrical Engineer*. A comparison of the two methods will be of interest.

As earth currents are the cause of electrolysis difficulties with the d.c. traction systems, these earth currents which stray away from the bonded rail return circuit of a.c. railways are the cause of all the troubles due to inductance. The problem then resolves itself into providing means of confining the current of the grounded return circuit and keeping it within bounds. Where the rail currents are allowed to leak off into the ground they frequently follow a very deep path in their return circuit back to the power house, being in many cases, undoubtedly, several thousand feet below the surface of the ground. This return current flowing at such a depth will, of course, have little or no effect in neutralizing the induction of the current flowing through the trolley wire, and the trolley current will then have free rein in causing all manner of disturbances in the adjacent telephone and telegraph lines. Where the return current is confined to the rails, however, or carried back to the power house by a separate feeder the inductive effect of the trolley current will be approximately neutralized by the inductive effect of the rail current or return flow current.

As described in the May, 1914, issue of the *Railway Electrical Engineer* virtually a three-wire system is employed on the New Haven, the rails being the neutral wire. A transmission voltage of 22,000 volts is employed, there being 11,000 volts between trolley and rails. Auto-transformers located every two miles along the right-of-way supply the 11,000 volt current for the car and incidentally withdraw all traction current from the rails at each transformer position so that the only current flowing in the rails is that secondary current flowing from the auto-transformers to the locomotive. The return current is thus confined within proper bounds and the inductive disturbances on telegraph and telephone lines is reduced to a minimum.

In the Pennsylvania electrification at Philadelphia, where 11,000 volts single-phase current is also employed as motive power, booster transformers are installed across insulated rail joints located about a mile apart. The primaries of these booster transformers being wound on a 1 to 1 ratio and connected in the main trolley circuit, force an equal amount of current to flow through the secondary coils and the rails at the point at which the booster transformer is located.

In other words, these booster transformers have the effect of gathering up the stray ground currents and forcing them to flow back again through the rails. The inductive effect of the trolley current on adjacent telephone and telegraph lines is then approximately neutralized by the inductive effect of an equal amount of current flowing through the rails.

In comparing these two methods it will be noticed that whereas the New Haven system has twice the transmission voltage that the Pennsylvania has, and consequently requires but half the transmission current, with half the inductive effect, the New Haven transformers being insulated for 22,000 volts are necessarily much more expensive than the Pennsylvania booster transformers, being wound for only 11,000 volts. It would seem that the Pennsylvania installation might prevent the flow of earth current just as effectively as does the New Haven system and at a considerably lower transformer cost on account of the lower voltage employed.

K. R. Hare Joins Railway Electrical Engineer Staff

Mr. Kenneth R. Hare, formerly chief electrician of the Northern Pacific Railway, has been appointed associate editor of the *Railway Electrical Engineer* with headquarters at the New York office of the company. Mr. Hare is a graduate of the University of Wisconsin, class of 1911, and after leaving school spent a year at the Schenectady works of the General Electric Company. In the fall of 1912, he was appointed chief electrician of the Northern Pacific Railway where he received a wide experience in connection with railway train lighting, shop motor and general construction work.

Electrification of the Pennsylvania at Philadelphia

The electrification of the suburban service of the Pennsylvania between Broad Street station, Philadelphia, and Paoli is the first work of this nature undertaken by that company in the vicinity of Philadelphia. Its primary purpose is to increase the capacity of the Broad Street station and thus relieve congestion at that terminal. This station is of the stub-end type, having 16 station tracks approached by six main line and three yard tracks on an elevated railroad which crosses the Schuylkill river from West Philadelphia. At this point the routes divide toward the north for New York, toward the south to Washington and toward the west to Pittsburgh.

In addition to the through passenger service accommodated at Broad Street station, there is an extensive suburban service extending over six different routes. The growth of all business in recent years has been such that the limit in capacity of the station has been reached and many plans have been formulated and discussed for relief by physical enlargement of the station and its approaches, or by rerouting movements. All of these plans involved extensive reconstruction and required much time for their accomplishment so that some more expeditious method of obtaining relief was desirable. The possibilities of electric traction as a means to this end were studied by committees of operating officials. Their analyses and estimates indicated that during rush hours the relief which would be secured by the electrification of the Paoli suburban service alone would increase the station capacity by an amount equivalent to reducing the total number of trains by about 8 per cent. A similar increase in capacity would result from the electrification of other suburban lines; work in connection with one of these, the Chestnut Hill Branch, has already commenced. This increase in capacity is effected by the elimination of the shifting back and forth from one track to another of cars, while the movement of light power is avoided. There is also some gain in capacity resulting from the quicker acceleration of trains and the shorter length of track occupied by a given train when the steam locomotive is not required. Relief thus afforded by the electrification of the Paoli and Chestnut Hill lines is estimated to be sufficient to take care of the normal growth of business for the next seven or eight years and the period of relief can be further extended by the electrification of other suburban lines, should the trial of this initial electric service meet expectations.

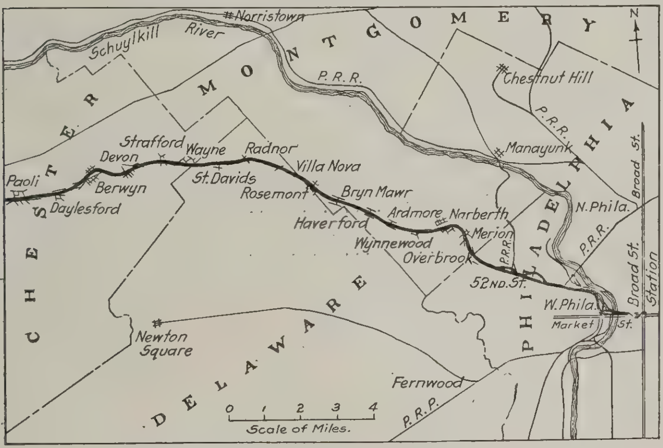


Fig. 1. Map Showing Electrified Portion of the Pennsylvania Railroad Between Philadelphia and Paoli.

It is estimated that under electric operation there will be a sufficient saving in operating costs, as compared with steam, to pay interest on the investment, which in this case is exceptionally large for the reason that the entire Broad Street terminal, with its elaborate yard and approaches, form a part of the construction required for a relatively small amount of train service. This is not an unfavorable result under the circumstances, meaning as it does that the increased capacity thus obtained will in part, at least, be self-sustaining, whereas increased capacity by physical enlargement would give no direct return on the heavy investment. In addition there are the other contingent and important advantages of electrification such as the higher speed of trains, more punctual service, especially in bad weather, and more cleanly and attractive conditions for the traveling public.

The Electric System.

A careful study of all phases of the problem, including service conditions, first and operating costs, available power supply, and the possible future electrification of the entire divisions affected, led to the conclusion that the most desirable system was one which used a high voltage, single, overhead contact wire and which eliminated rotating machinery in substations. It was, therefore, decided to supply 11,000-volt, single-phase, 25-cycle power directly to the cars from a single overhead catenary trolley.

While the studies which preceded this work involved the possible future electrification of several different railway divisions and classes of service, the present installation covers only the suburban service from Philadelphia westerly to Paoli on the main line of the Philadelphia division and involves about 43 trains each way per day. From Broad Street station the main tracks are electrified for 20 route miles, including a coach yard at West Philadelphia and a coach and repair yard at the end of the electrified section at Paoli. The present electrification embraces about 93 miles of single track.

Power Supply.

Power for traction purposes is purchased from the Philadelphia Electric Company and is generated in its main power station at Christiansen street on the east bank of the Schuylkill river about a mile south of the West Philadelphia passenger station.

The power is delivered to the railroad company's Arsenal Bridge substation directly across the river, at 13,200 volts. There it is stepped up to 44,000 volts and by means of duplicate single phase overhead transmission circuits is transmitted to the step-down substations. While the present service is on one phase only of the power company's three phase generating system, the plan is to supply the succeeding or future electrification power requirements from the remaining phases. Special provision has been made by the power company to balance this single phase load and also to correct for the relatively low power factor in order that the full three phase capacity of the generating units may be available.

Transmission.

Three-phase, 25-cycle power at 13,200 volts is transmitted from the Philadelphia Electric Company's generating station to the railroad company's Arsenal Bridge substation over four 350,000 C. M., 3-conductor armored submarine cables laid on the bed of the river. On the west bank of the river the submarine cables are connected to paper-insulated, lead-covered cables, which lead through clay ducts into the substation. Switchboard meters are provided on each of the incoming 13,200 volt feeders.

From the Arsenal Bridge substation to the West Philadelphia substation power at 44,000 volts is transmitted over four aerial single phase transmission lines.

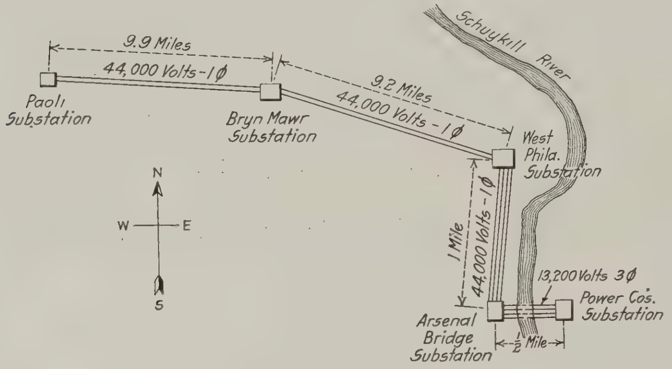


Fig. 2. Schematic Diagram of the Single-Phase, High-Tension Feeders Between the Philadelphia Electric Company's Power Station and the Railroad Company's Substations. Each Line Represents a Two-Phase Feeder.

All four of these single phase lines tee into the West Philadelphia substation, two of them continuing on to the Bryn Mawr and Paoli substations. The other two will later go to the Chestnut Hill substation.

Between the Arsenal Bridge and West Philadelphia substations the four single phase transmission lines are carried on four two-pin steel cross arms attached to a structural steel pole which is supported by steel brackets from the side of the elevated structure. Beyond the West Philadelphia substation the lines are carried on the catenary supporting structures. Along the right-of-way the lines are carried on both sides of the track. Horn gap switches for sectionalizing are installed on the roofs of the West Philadelphia, Bryn Mawr and Paoli substations. Lighting arresters are installed on the roofs of all substations.

Each of the single phase transmission lines consists of two No. 00 seven strand, hard drawn copper wires. Wires of the same circuit are spaced 5 ft. apart on the cross arms. Where there are more than one circuit on a pole, the vertical spacing is 3 ft. 6 in. The lines are protected by a ⅜ in. stranded steel ground wire on the top of the poles.

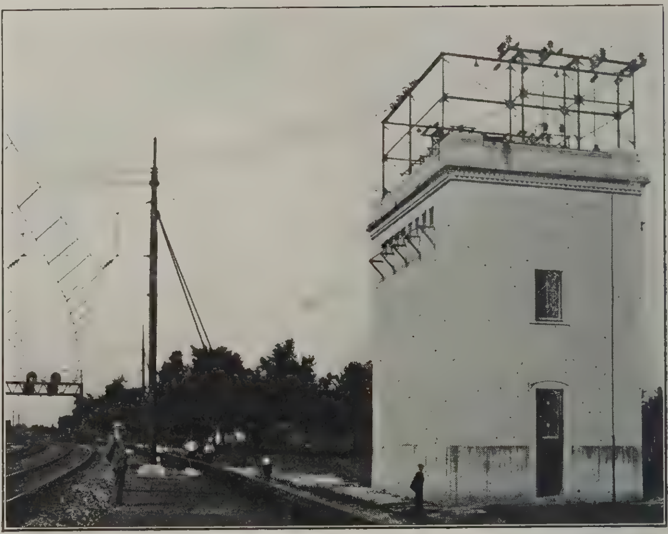


Fig. 3. Transformer Substation at Paoli, Pa., Showing Equipment on the Roof and Method of Bringing Out High-Tension Trolley Feeders.

Under the Belmont and Girard avenue bridge, which on account of its width approaches tunnel conditions, the lines are covered with rubber and varnished cambric insulation. At either side of the bridge the insulation is tapered off inside a porcelain sleeve filled with compound. The wire continues on through the sleeve and is jointed with the bare wire outside.

The pin type porcelain insulators used on the transmission lines are 8 7/16 in. high and 12 in. in diameter, and are made up of four parts. These insulators withstand the following tests:

Dry flashover	165,000 volts
Wet flashover	120,000 volts
Puncture	250,000 volts

After erection, the transmission lines were tested out at a potential of 66,000 volts, or three times the working pressure, to ground.

At the Arsenal Bridge substation the lines are protected by time limit relays which operate on overload and on an unbalanced load in either leg caused by a ground. In the other substations the relays operate only differentially. In case of a ground between substations, the circuit on which the trouble occurs will be cut out first in three of the substations and finally at the Arsenal Bridge substation.

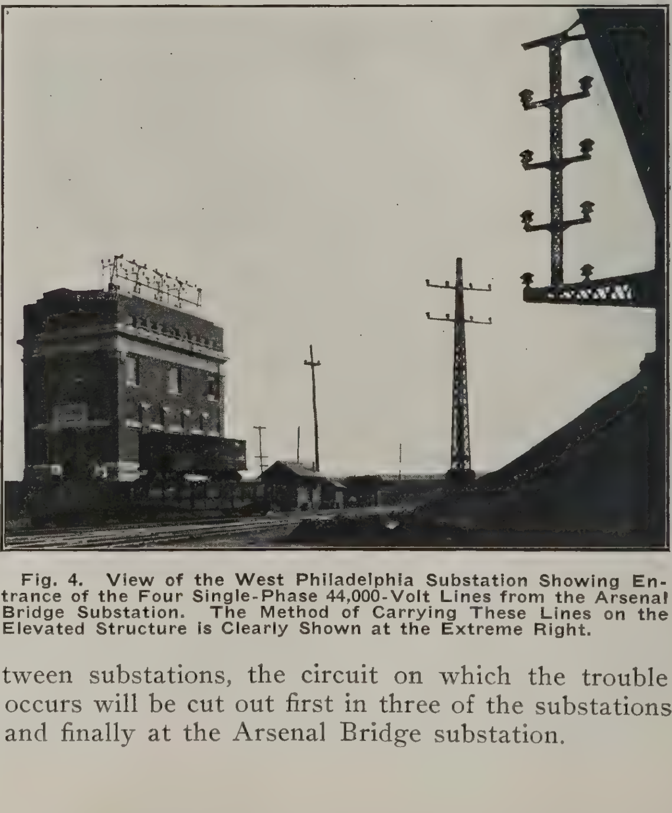


Fig. 4. View of the West Philadelphia Substation Showing Entrance of the Four Single-Phase 44,000-Volt Lines from the Arsenal Bridge Substation. The Method of Carrying These Lines on the Elevated Structure is Clearly Shown at the Extreme Right.

Substations.

Transformer substations are provided for stepping up the voltage for transmission and for reducing it at suitable points along the railroad to that required for the contact conductors.

The substation equipment is housed in substantial fireproof brick buildings adjacent to the tracks. The lightning arrester equipment and high tension feeder sectionalizing switches are located on the roof, the bus bars and switching equipment on the second floor, and the transformers on the ground floor.

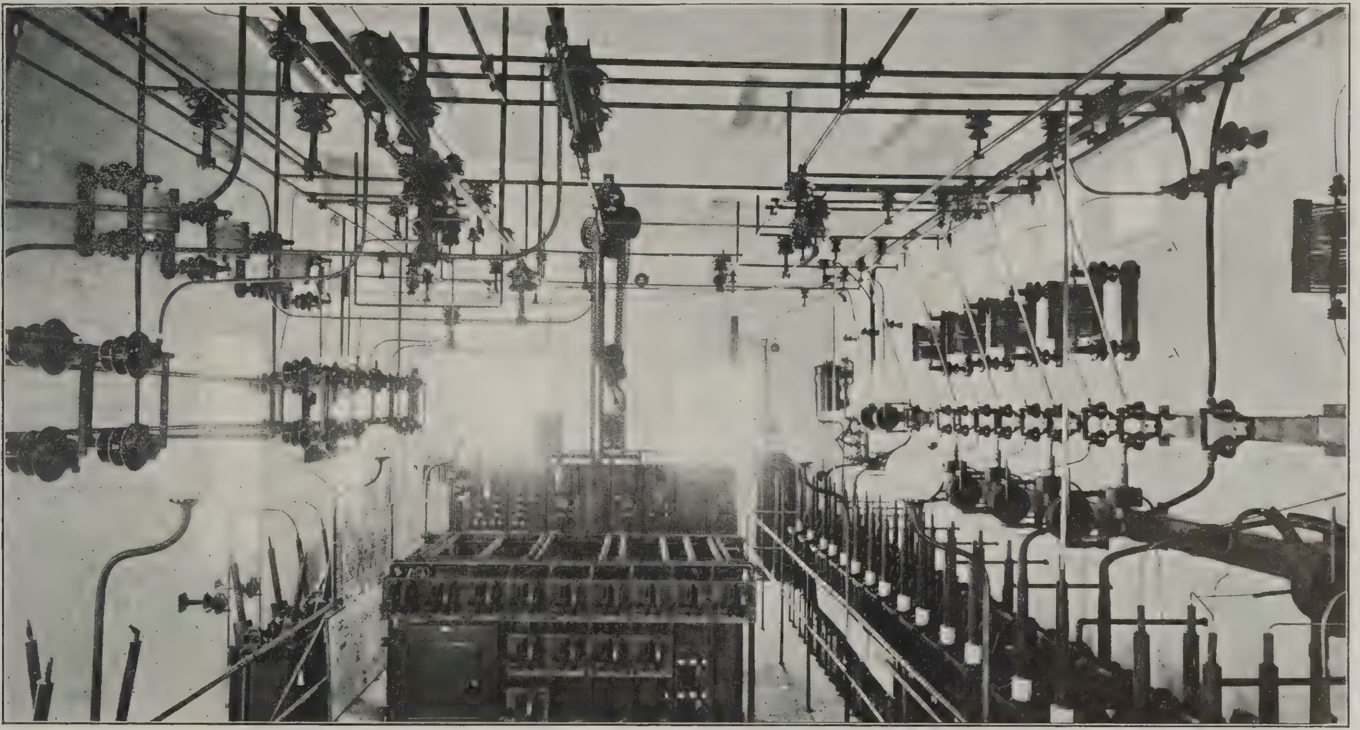


Fig. 5. Arrangement of Bus-Bars and Switching Equipment in a Typical Substation.

The installed capacity of the substations are as follows:

Arsenal Bridge........	3—5,000 K.V.A. step-up transformers
West Philadelphia.....	2—3,000 K.V.A. step-down transformers
Bryn Mawr...........	2—2,000 K.V.A. step-down transformers
Paoli	2—2,000 K.V.A. step-down transformers

Space is provided in all substations for 100 per cent. increase in capacity.

The transformers in all substations are of the 25 cycle, single phase, oil-insulated, water-cooled type. The primaries of the step-up transformers in the Arsenal Bridge substation are wound for 13,000 volts, the secondaries for 44,000 volts. The primaries of the step-down transformers in the other substations are wound for 44,000 volts, the secondaries for 11,000 volts. Several voltage taps are provided on the primary and secondary coils of all transformers. In each substation a transformer truck and chain hoist are provided for handling the transformers and cores. Each transformer case is also equipped with a thermostat which operates an alarm bell in case of high temperature in the transformer. Oil filtering and drying apparatus is located in each substation and a tank is provided into which the oil may be drawn from the transformers.

The neutral points of the high tension windings of the step-up transformers are grounded through a grid resistance. The potential to ground from either side of the 44,000 volt transmission lines is, therefore, limited to 22,000 volts.

Power at 110, 220 and 440 volts and 25 cycles for the operation of oil switches, for electric lights and for other miscellaneous purposes, is obtained from the high-tension buses through suitable step-down transformers.

In addition, an emergency supply of 60 cycle power is provided in all substations to trip circuit breakers in case of the loss of the 25-cycle traction power.

Except in the West Philadelphia substation where the power director or system operator is located, there are no attendants. A switchboard with the necessary instruments, controllers and indicating lamps, is provided in signal towers near the Arsenal Bridge, Bryn Mawr and Paoli substations. This board is connected with the board in the substation through a control cable, which arrangement permits the tower man to open and close all circuit breakers in the substation from his station in the tower. Telephones are provided in all substations and in the signal towers controlling them so that the power director is in constant touch with all substations and tower men. An alarm bell connected to the thermostat on the transformers is located in each signal tower.

Catenary System.

In order to try out the various types of structures and details considered for this work, an experimental four-track section about a mile long was completely equipped in the fall of 1913. An examination and study of this led to the adoption of what is called the "tubular cross-catenary bridge" for carrying the catenary trolley wires.

A photograph is shown of one of these structures before any longitudinal wires were erected. On either side of the tracks a tubular steel pole is set and grouted into a concrete foundation. Each pole has a double guy anchoring it away from the tracks. Spanning the tracks between the poles are the two cross wires forming the cross catenary bridge which carries the longitudinal messenger and trolley wires. This type of structure has been used throughout wherever the property or arrangement of tracks will permit. Where there is no room for guying, self-supporting structural steel posts have been used.

The tubular poles are built of various lengths, sizes and weights of steel pipe welded together. The guys are solid steel rods with heavy turnbuckles near the ground end to permit of adjustment. Numerous experiments and tests were made to determine the holding power and economy of various forms of guy anchors. The anchors finally adopted are of the deadweight type, each consisting of a concrete slab reinforced with old rails. Where the guy rods pass up through the soil they are protected against corrosion by means of a steel pipe, the space between the pipes and the rod being filled with grout. The guy rods are attached to the pole by heavy steel castings.

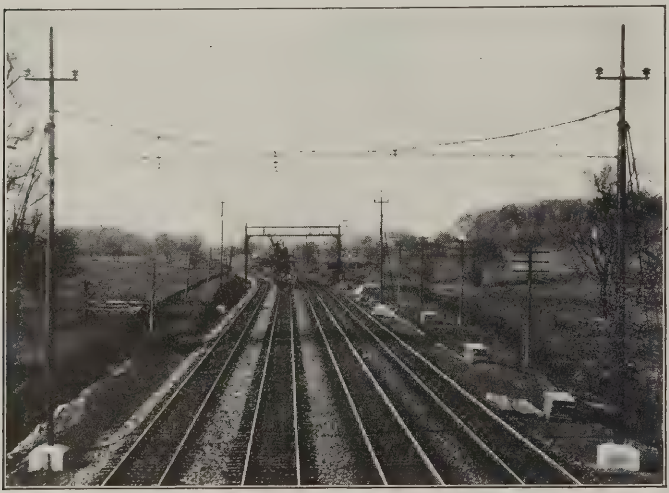


Fig. 6. Tubular Cross-Catenary Bridge Before Longitudinal Wires Were Erected.

The cross wires are of extra high-tension galvanized steel strand, the upper strand usually being ¾ in. and the lower one ½ in. in diameter. Both are socketed at each end, and at one side a turnbuckle is installed to permit adjustment. The top and bottom cross wires are joined together by a ¾ in. vertical rod and suitable malleable iron clamps, etc., at the points where the insulators carrying the longitudinal wires are located.

Each of the insulators that are supported by the cross catenary wires consists of three suspension type units, the porcelain being 8 in. in diameter. The flashover value of the complete insulator is many times that of the line voltage. The cross wire bridges are located about 300 ft. apart on tangents, but are closer on curves. After the bridges were erected, insulators were suspended over the center of the track on tangents and offset towards the outside of the track on curves. The main messenger wire was then strung out and suspended from them. This is a ½-in. extra high tension 7-strand double-galvanized steel cable, having a sag of 5 ft. in a span of 300 ft. Every mile or two this messenger is socketed and dead-ended on one of the heavy structural signal bridges which are placed about ½ mile apart. Where so dead-ended the messenger is insulated from the signal bridge by two or more sets of the three unit suspension type insulators used for suspending the messenger from the cross wires on other bridges.

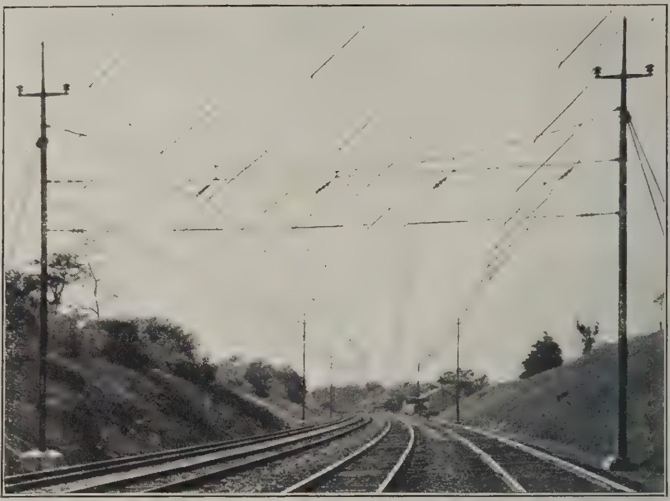


Fig. 7. Catenary System Over Curved Track.

An auxiliary messenger wire and the contact or trolley wire are suspended from the main longitudinal messenger wire by suitable hangers. The hangers are placed 30 ft. apart over tangent track and 15 ft. apart over curved track. On tangents, the casting at the bottom of the hangers holds the auxiliary messenger only; the trolley wire is then supported from this auxiliary messenger every 15 ft. at points midway between the hangers. This insures a flexible and smooth riding trolley wire. On curves the casting at the bottom of the hangers holds both the auxiliary messenger and trolley wire. Except at overhead highway bridges the trolley wires are carried about 22 ft. above the top of the rail.

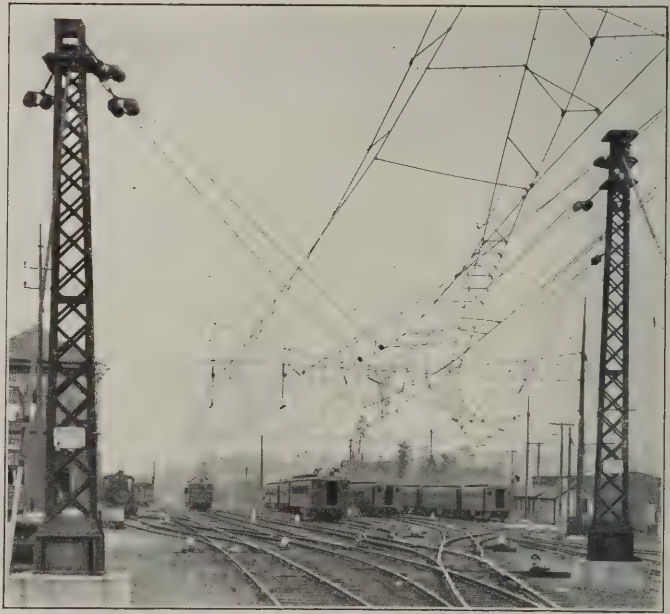


Fig. 8. Catenary Construction at the Paoli Yard.

In the Terminal division, which includes the first five miles from Broad Street station, where the steam locomotive traffic is very dense, and where there is much smoke and corrosive gas, a non-corrodible tube hanger is used. Some of the tube is Monel metal,

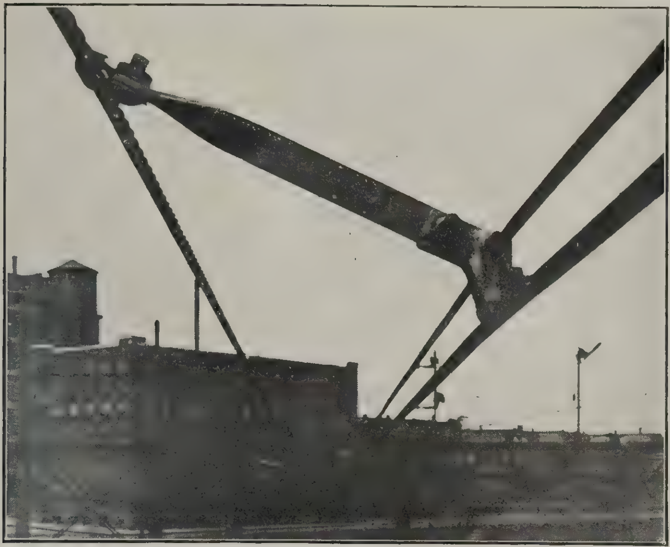


Fig. 9. Wrought Iron Trolley Hanger and Method of Its Attachment to the Wires in Curved Track Construction.

while the balance is a bronze mixture containing 90 per cent. copper. On the Philadelphia division, where there is relatively less steam traffic, wrought iron strap hangers, 1 in. wide by 3/16 in. thick, are used. The main messenger cable at the hanger clip is protected from corrosion by a collar of zinc inside of the annealed brass or Monel metal clip, which is bolted to the hanger strap. The flat hangers were given a quarter turn so as to have the widest dimension in a vertical plane, the idea being to minimize the area exposed to the wind in a direction crosswise with the tracks, and also to better resist bending when placed on curves.

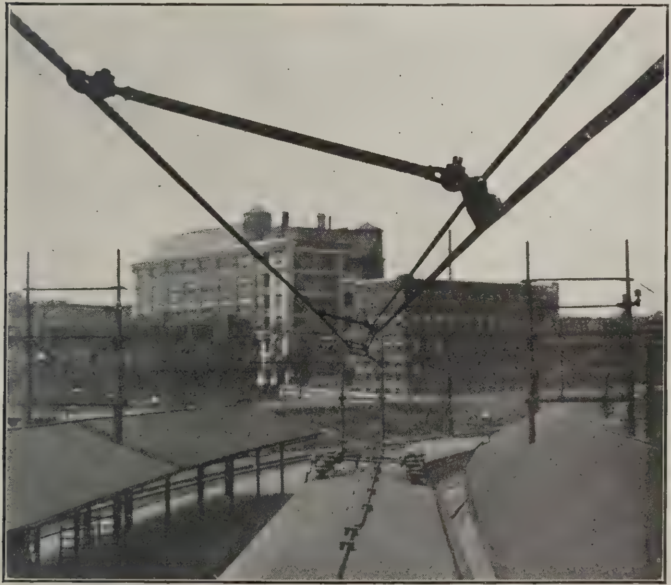


Fig. 10. Non-Corrodible Tube Trolley Hanger.

The auxiliary messenger wire is of No. 0 round B. & S. solid copper, and its purpose is to give the necessary current capacity to the system. The contact wire is a No. 000 grooved B. & S. "Phono-electric" trolley wire.

The tensions in both the auxiliary messenger and trolley wires are selected so that in extreme hot weather there will be enough tension to prevent sagging and yet in extreme cold weather the contraction will not cause stresses beyond the elastic limit.

The catenary system over each of the four main tracks is separated electrically from those over the other tracks, and trolley sectionalizing points with switches are provided at all crossovers so that sections of the line may be temporarily cut out of service for repairs.

On the main running track sectionalizing is of the "air-brake" type, the trolley wire of one section passing the trolley wire of the other section at the same level so that the pantagraph may come in contact with both. The ends of both trolley sections are then raised, insulated and dead-ended.

At crossovers and in yards the trolley wires are sectionalized by means of wood stick insulators, having runners on each side so arranged that while the pantagraph always makes contact with at least one of them they are separated electrically. Switches of the disconnecting knife blade type are mounted on top of the wood insulators. They are operated from the ground by a long impregnated wooden switch stick.

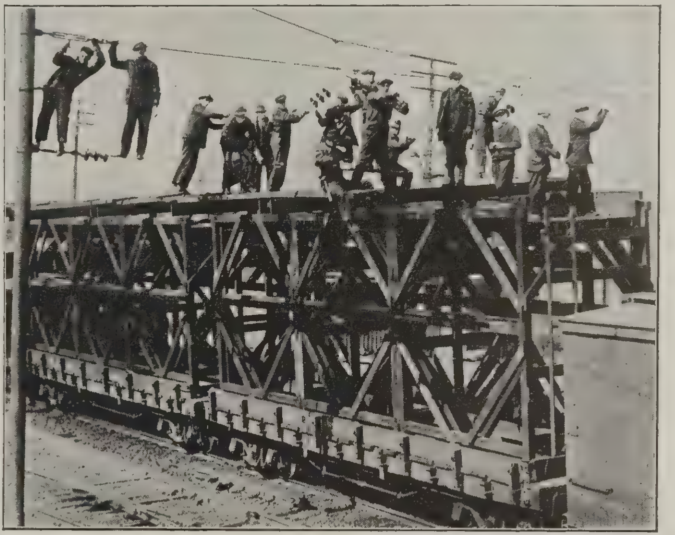


Fig. 11. Special Car for Erecting Catenary Work; Removable Outriggers Make It Possible to Work Over Adjacent Track Without Interruption to Traffic.

The electrified route is crossed in many places by overhead highway bridges, some of which are not high enough above the tracks to permit the trolleys being carried at the normal height of 22 ft. In such cases if it was impracticable to raise the highway bridge the trolley wires gradually dip and go under the bridges at a height less than 22 ft.

The catenary bridges are so located that these highway bridges come in the center of a span where the vertical height necessary to clear the catenary system is a minimum. Each catenary system, as it passes under a highway bridge, is steadied by being held with post type insulators mounted on brackets fastened to the bridge structure.

To prevent pedestrians on the bridges from touching or interfering with the wires solid wooden fences, either vertical or inclined, and of sufficient height to shut out all view of the wires, have been erected. In order fully to protect the trainmen, general orders have been issued that no men are allowed on top of any car in the electrified zone.

An interesting detail in the erection of this catenary work was the use of special construction cars, the top platforms of which could be readily raised or lowered by chain hoists. These cars were also equipped with removable outriggers so that in the four-track section the work could be completely erected over a track adjacent to the one on which the car was standing without interfering with the regular steam traffic on that track.

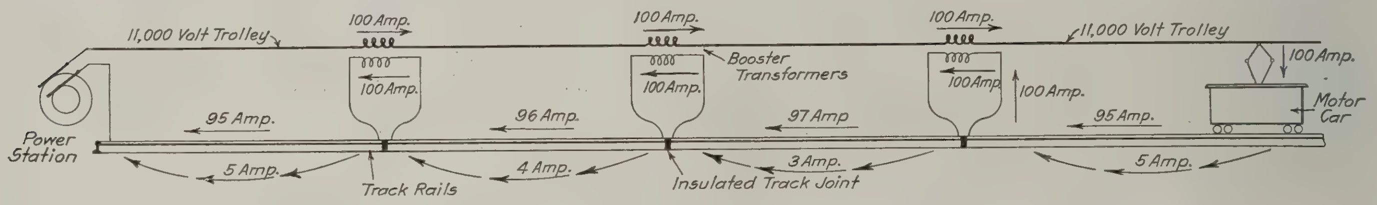


Fig. 12. Elevation Diagram Showing Booster Transformer Connections. The Arrows at the Bottom Indicate the Action of the Transformers in Gathering Up the Ground Currents at Each Transformer Location.

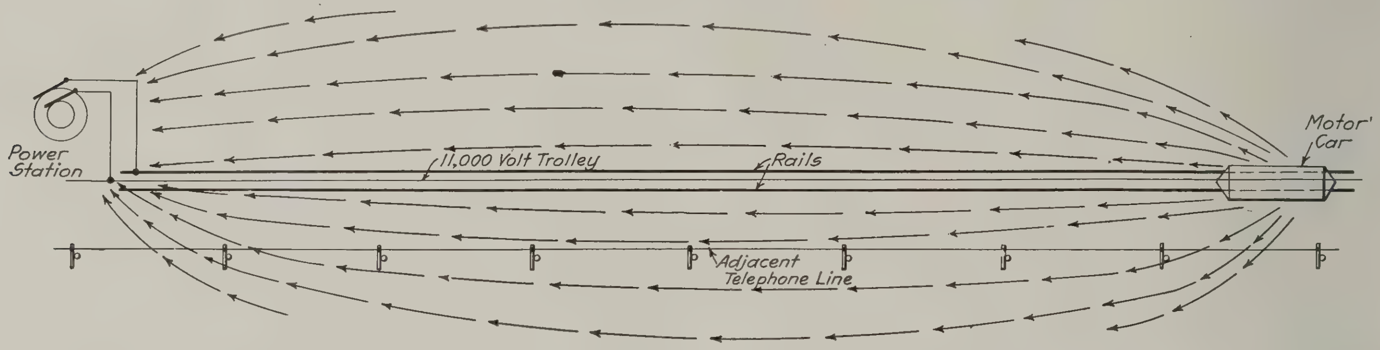


Fig. 13. Plan View Showing Large Amount of Ground Currents Flowing Between Motor Car and Power Station When Booster Transformers or Some Other Corrective System is not Employed.

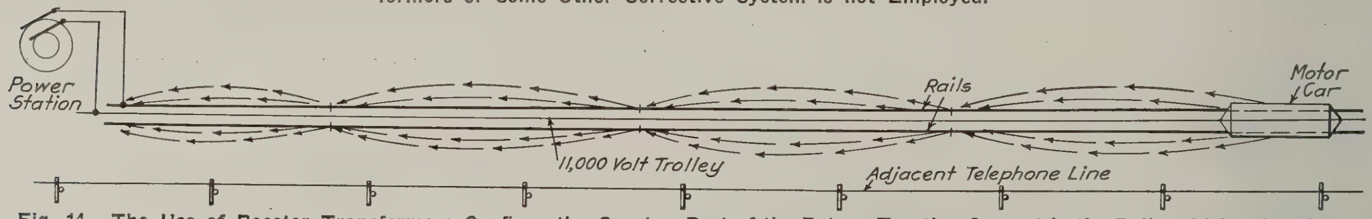


Fig. 14. The Use of Booster Transformers Confines the Greater Part of the Return Traction Current in the Rail and Thereby Eliminates Objectionable Inductive Effects on Adjacent Telephone and Telegraph Lines.

Bonding.

In order to furnish a circuit for the return of the traction current to the substations, each rail joint of the main line tracks is double bonded with two pin type, expanded terminal, No. 0 B. & S. bonds. One end of each bond has a welded terminal, while the other end has a soldered terminal. With this arrangement it is possible to install the bond by slipping it behind the splice plate. Through the interlockings only one rail of each track is bonded. The bonded rails of the various tracks are, however, connected together.

The track rails are sectionalized at each signal block by insulating joints, across which are placed impedance bonds. These impedance bonds allow the passage of the traction current, but sectionalize the track so far as the 60-cycle signal current is concerned.

Booster Transformers.

To minimize the inductive effect of the traction current on adjacent telephone and telegraph wires, a special system has been installed. This consists of series or booster transformers located about a mile apart. These transformers are mounted on the signal bridges and the current in each of the trolleys is constrained to pass through a primary coil of the transformer, thus inducing an equal current in the secondary coil, the ratio of the transformers being approximately unity. The secondary coils of these transformers are connected across insulated joints in the track. Consequently as all trolley current must flow through the primary coil the secondary coil insures that all the returning traction current, at this particular point of the circuit at least, must pass through the rails. In this manner the traction current is prevented from taking earth returns in parallel with the track or if there is a tendency between these booster transformers for the traction current to seek an earth return this tendency is corrected at the next booster transformer which constrains or picks up all the traction current and again starts it through the rail. A typical signal bridge with these booster transformers is shown in Fig. 17. By thus confining the return traction current in or near the rails and therefore keeping it as near the trolley as possible, its inductive effect on adjacent telephone and telegraph lines is practically eliminated. This is of course in complete harmony with the laws governing mutual inductance which are to the effect that the closer two wires of the same circuit are to each other the less their self-inductance and therefore the less their mutual inductance on a near-by parallel circuit.

Diagrammatic sketches showing how the use of booster transformers confines the return traction current to the rail, thereby eliminating its inductive effects on parallel telephone and telegraph lines, are shown in Figs. 12, 13 and 14. The transformer connections and the current distribution are shown in Fig. 12. It is, of course, understood that the sketch shows a rather ideal condition. In actual practice small, negligible ground currents will no doubt flow on past the insulation joints, in which case the booster transformer will cause an equal current to flow in the reverse direction around the insulation joint through the ground so as to bring the value of the secondary current up to that of the primary or trolley current. The wide spreading of the return traction current that would be expected in case no booster transformers were employed is illustrated in Fig. 13. Fig. 14 shows that, by using the booster transformers the amount of current seeking a ground return is reduced to a minimum.

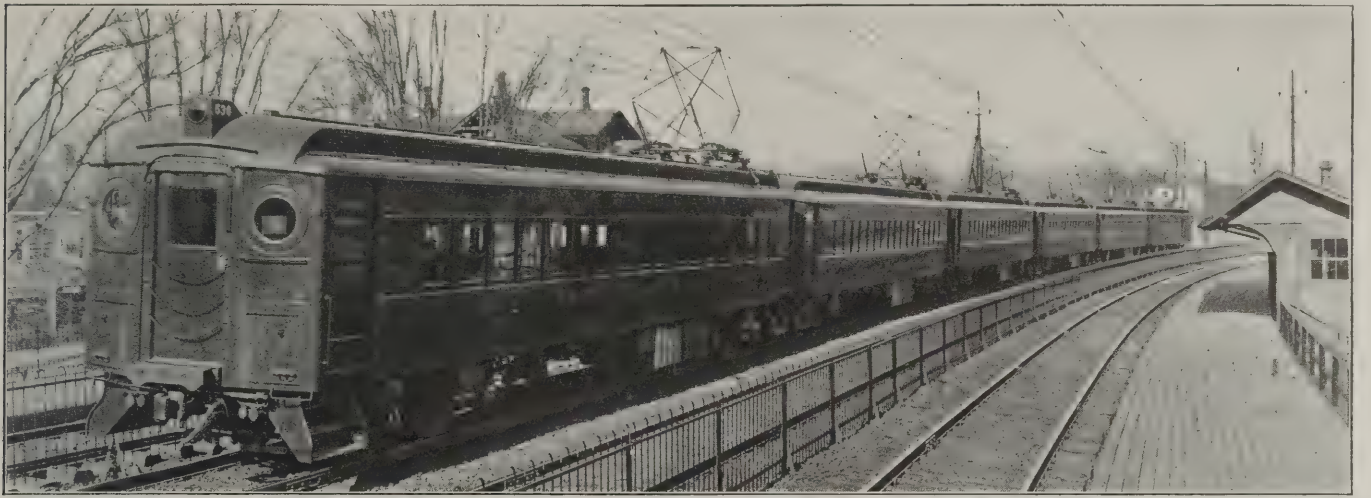


Fig. 15. Multiple Unit Train on the Electrified Portion of the Pennsylvania Between Philadelphia and Paoli. Each Car is a Motor Car, No Trailers Being Used.

Car Equipment.

One of the interesting features of the electrification was that the standard suburban steel coaches of the type used in the regular steam service have been used for the electric service without structural changes. This was made possible by the fact that the requirements for mounting electrical apparatus on the cars had been thoroughly considered at the time when the steel car was introduced on the railroad. A typical multiple unit train is shown in Fig. 15.

The rolling stock equipped for electric service consists of 93 standard all-steel cars. Tighty-two are passenger, nine combined passenger and baggage, and two combined baggage and mail. All cars are motor cars designed for double end operation. No trailers will be used.

The main circuit connections are shown schematically in Fig. 16. Current is collected from the overhead wire by a pantagraph trolley and is conducted to the main transformer through the line switch which is an oil circuit breaker. Various voltage taps are made on the secondary of the transformer and connections are made to these various taps in the proper sequence by means of unit switches. This sequence is also indicated by Fig. 16.

The motors, which are connected in series, are started and operated up to approximately 15 m.p.h. as repulsion motors, with the auxiliary or compensating field, the armature, and the main field in series. With these series connections, the armature is short-circuited through resistance. Resistance is also inserted in series with the motors on the first step and is cut out on the second step. The third step changes the connections to energize the auxiliary field from one portion of the transformer and the armature and main field, connected in series, form another portion of the transformer, thus affording doubly fed connections. The armature short-circuit is removed when operating as doubly fed motors. Subsequent steps are obtained by increasing the voltage across the auxiliary field and across the motors.

Each motor has an hourly rating of 225 h.p. and a continuous rating of 200 h.p. with 300 volts across the armature circuit when ventilated with 1,200 cubic feet of air per minute, and is provided with a 24-tooth pinion which meshes with a 55-tooth flexible gear. The armature is of standard construction, the commutator and the laminations being mounted on the spider, the former being undercut 1/16 in. The armature is wave-wound, cross-connected and no resistance leads are used between the windings and the commutator. The field windings consist of two entirely independent sets of coils; one, the main field circuit for producing the effective magnetic field; and the other an auxiliary or compensating winding which balances the armature reaction on the field and, in addition, has a neutralizing effect on the sparking voltage. The field consists of six poles, the coils being of copper bars suitably insulated, connected at the ends by straps.

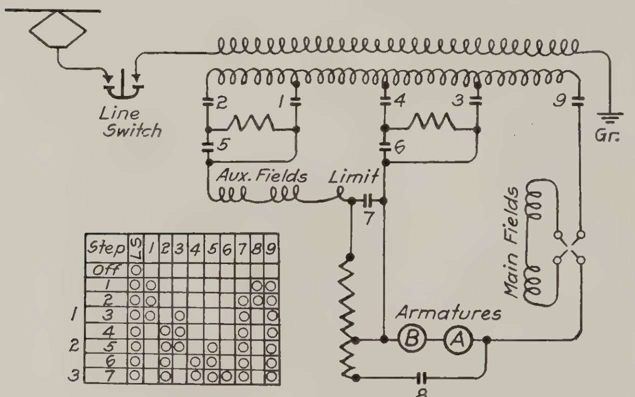
The flexible gear, as shown by Fig. 18, is made up of a rim, on which the teeth are cut, a center, a cover plate and spring details. The rim is spring mounted on the center, the periphery of the center and the cover plate acting as the bearing surfaces for the rim.

The pantagraph is of especially light construction. The springs which raise it are designed to give flexibility to the framework, so that in operation a slight dragging of the trolley takes place, resulting in its following the wire much closer than with a rigid framework. In addition, the shoe is spring mounted on the framework. The trolley is provided with four insulators suitable for 11,000 volt service, and the whole mechanism is mounted on a base provided with insulators similar to those of the trolley, thus providing double insulation. The trolley is lowered and unlocked by air at 70 lb. pressure. A small hand pump is provided for unlocking the trolley when no air pressure is available.

The transformer is of the two-circuit air-blast type and is suspended from the center sill of the car as close to the motor truck as possible. The high tension leads are brought in the end of the transformer nearest the motor truck and the low tension leads are taken from the opposite end of the transformer. Ventilating air is taken in at the low tension end and is discharged at the high tension end through especially constructed hoods which cover the air outlets to prevent the entrance of rain and wheel wash. The coils are mounted vertically and are bakelized, thus giving an insulation which will withstand high temperature without damage.

Nine electro-pneumatic operated switches of standard construction are mounted in one group. The right hand end plate of this group is provided with covers and forms the base for the reverser. The current limit and the control terminal board are also mounted on this end plate, at the right-hand side of the reverser. The reverser drum is built of bakelized micarta tubing on which are mounted the contact plates, and is electro-pneumatically operated.

The limit switch is of novel construction. The current coil which is connected in the auxiliary field circuit of the motor surrounds a plunger which carries the control contact disc. The two settings of the limit switch are obtained by changing the weight of this plunger. This is done by lifting a weight from the plunger by means of a battery coil mounted above the current coil.



	Step	LS	1	2	3	4	5	6	7	8	9
	Off	○									
	1	○	○							○	○
	2	○	○						○	○	○
1	3	○	○		○				○		○
	4	○		○	○				○		○
2	5	○		○	○		○		○		○
	6	○		○		○	○		○		○
3	7	○		○		○	○	○	○		○

Fig. 16. Schematic Diagram Showing Connections of the Doubly Fed Motors.

The master controllers are of the single handle type. Two plug receptacles are embodied in this controller and a single plug is attached to the handle by a chain. Placing the plug in the "cutout" receptacle completes the circuit energizing the line switch valve magnet and also connects the controller drum to the battery positive wire. Placing the plug in the "reset" receptacle connects the reset-wire to the battery positive train line wire. Nine controller positions are provided; an emergency or "dead man's" position in the center, and an "off," first, second and third running positions, for both forward and reverse movements. The controller drum is spring returned, and if released, will return to the middle or emergency position. In this position, the control is cut off and a valve magnet is energized which releases air from and operates a brake pipe relay, thus applying the emergency brake. This emergency circuit is local for each car. Each controller also has two push button switches for unlocking or lowering the trolley. To unlock the trolley, the control plug must be in the "cutout" receptacle, but the trolley may be lowered without the plug being in place. Each controller is mounted at the right-hand side of the vestibule, together with the motorman's brake valve, the signal whistle and magnet, and the cab heating equipment. This is shown by Fig. 19. When not being used, the end vestibule door is swung back to cover all this apparatus.

Control energy is obtained from a motor generator set operating in parallel with a battery. The motor is of the single-phase induction type with a starting winding that is cut out of circuit when the motor has attained speed.

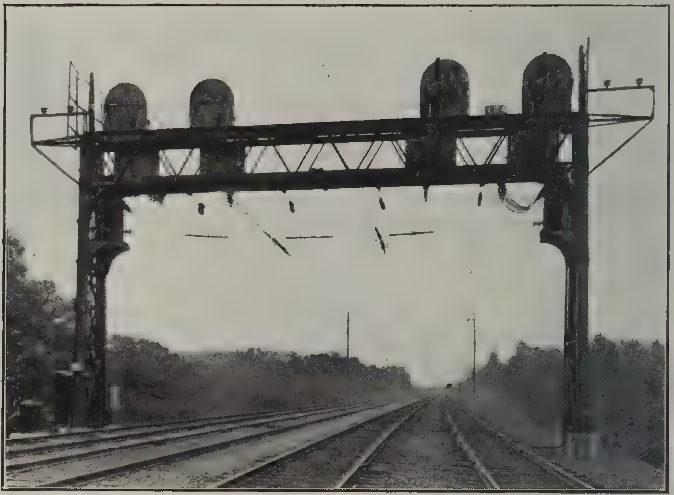


Fig. 17. Signal Bridge, Showing Anchor Insulators in the Main Catenary Messengers. A Booster Transformer is Shown Near the Top of Each Leg of the Bridge.

Ten control wires, including the battery plugs and ground wires, are required between cars for control operation. Nine of these are carried between the cars through a nine-point receptacle and jumper and the tenth is carried on the seven-point train line required for the electric brake circuits described later. The two nine-point control receptacles are mounted on each end of the car, one on each side of the coupler, and are connected in multiple.

A line or voltage relay is provided for cutting the d.c. control generator from battery, and also to operate two small emergency lights, and headlights in case the traction power should fail. This relay, together with the lighting fuses, control governor and heater switches and compressor motor switch, is mounted on a panel placed in the vestibule cabinet at the motor end of the car. This switchboard is of slate and all apparatus mounted on it is front-connected, thus facilitating inspection.

The fan for ventilating the transformer and motors is a 21 in. single inlet Sirocco wheel, and is mounted on the shaft of the motor which drives the compressor. The motor drives the fan continuously and the pinion driving the compressor is connected to the motor by a disc clutch. This clutch is normally held closed by a spring and the governor operates a magnet valve which opens the clutch by air pressure. The motor is of the doubly fed type and operates at approximately 980 r.p.m. at normal voltage with the combined loads of the fan and compressor, while the speed with the fan alone is approximately 1,300 r.p.m.

The air brake equipment of each car consists of two main reservoirs with radiating pipes, one safety valve on the main reservoirs, one compressor governor, two motormen's brake valves, with feed valves and reduction limiting valves, two combined equalizing and reduction limiting reservoirs, one emergency or quick recharge reservoir, one auxiliary and one service reservoir, one universal valve, one main reservoir bypass and limiting valve, one double check valve, one brake cylinder, one automatic slack adjuster, two duplex air gages, four seven-point train line receptacles, one seven-point train line jumper, one brake pipe, one main reservoir pipe, and one set of accessories, which includes cutout cocks, air strainers, hose, dirt collectors, switches, etc. This equipment is designed so that it may be used either in steam or electric service, and differs from the ordinary pneumatic brake in that the brake pipe reduction is made on each car by means of electric control instead of being made entirely with the engineer's brake valve. The addition of electric control to the pneumatic brake does not change its function in any way, but shortens the time required to get the brakes applied on all cars.

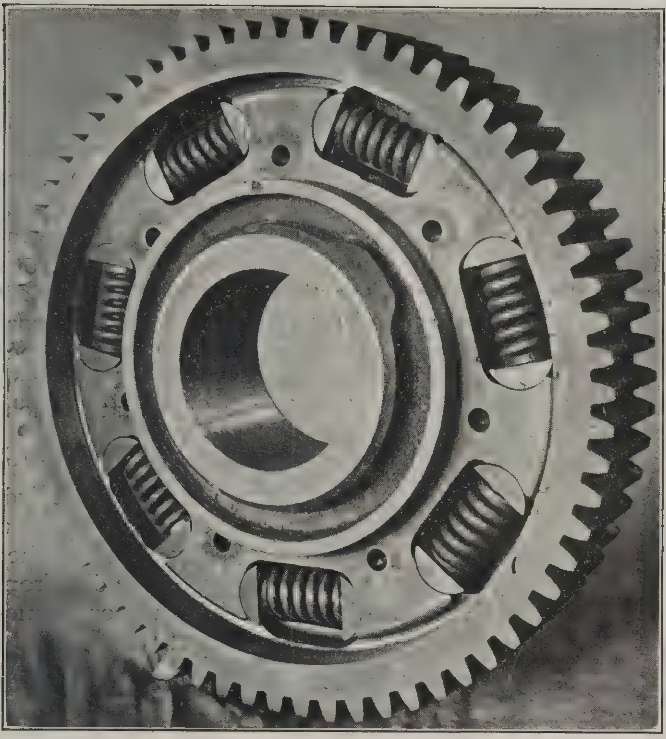


Fig. 18. Flexible Gear with Cover Plate Removed.

The motorman's brake valve contains both electric contacts and pneumatic parts, the electric portions being mounted above the pneumatic portions. There are six positions: (1) the release and running, (2), the electric holding, (3) the handle off, (4) lap, (5) service, and (6) emergency. The first named position is to the left and in this position all train brakes are released and the system charged. The "electric holding" position, as the name implies, holds the train brakes through electric control system but recharges the system. Pneumatically, this position is identical with the release and running position. All ports are closed in the "handle off" position, and the handle may be removed; in the "lap" position, the ports are also closed. The "service" and "emergency" positions are for applying the brakes for service or emergency application. In making a service application, a limiting valve in conjunction with the brake valve allows a maximum reduction of 20 lb. in the brake pipe. A small cutout plug is provided for cutting out the electric operation when desirable. The main reservoir pressure carried is 100 lb. and the brake pipe pressure is 70 lb.

Eight wires, including the battery plugs and ground wires, are required for the electric control of the brakes, for governor synchronizing and for train signaling. Since the two battery wires are common to the brake control and the unit switch control, a seven-point receptacle and jumper is used to carry the brake control wires. Two receptacles are mounted on each end of the car and on each side of the coupler and are connected in multiple in the same way as the nine-point receptacles for the unit switch control.

Trains of from two to seven cars are operated in regular service, the average acceleration on a straight level track being approximately one m.p.h.p.s. up to 30 m.p.h. with a balancing speed of 60 m.p.h.

Engineering and Construction.

The design and construction of the electric installation was carried out by Gibbs & Hill, consulting electrical engineers for the company, in co-operation with the engineering department and the officials of the road. All construction except that of substation buildings and inspection building, which were covered by outside contracts, was carried out by a specially organized force.

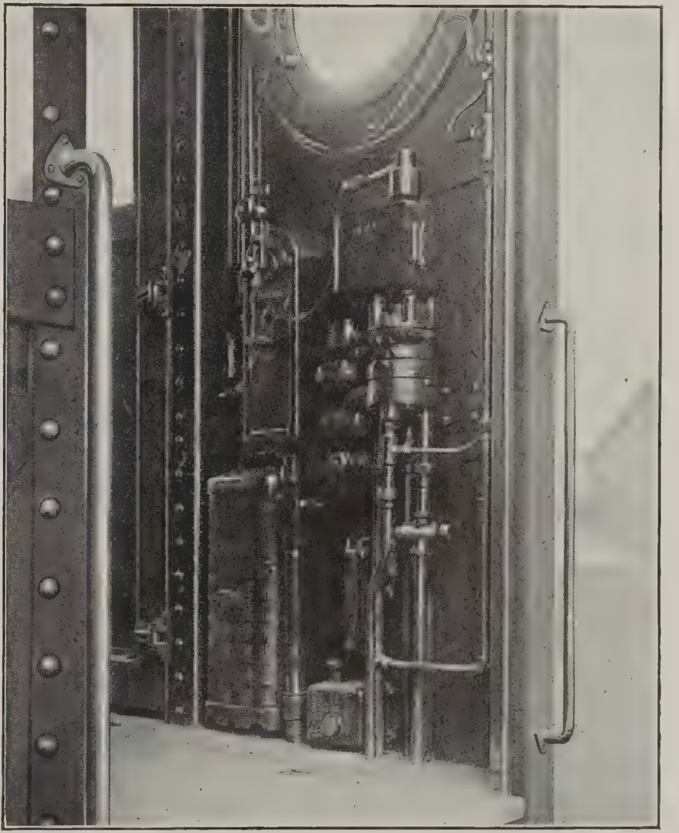


Fig. 19. Motorman's Position in Right Hand Side of Vestibule.

The mounting of the multiple unit car equipment on the cars was carried out by the railroad forces at the Altoona shops under the direction of the motive power department. The signal equipment and changes in telegraph and telephone lines were designed and installed under the direction of the signal and telegraph departments respectively of the railroad company.

Smoke Abatement Report of Chicago Association of Commerce

Abstract of the Million Word Report

The complete electrification of the Chicago railroad terminals as a means of abating smoke is technically practical, but financially impracticable. This is the finding of the Chicago Association of Commerce Committee of Investigation on Smoke-Abatement and Electrification of Railway Terminals, which has been studying the problem since early in 1911. The committee, in addition, holds that the elimination of steam locomotives alone would produce a hardly perceptible betterment of the Chicago atmosphere, and urges the appointment of a permanent Municipal Pure Air Commission which both through instruction and coercion shall reduce all sources of air pollution to a minimum.

The association committee, as a result of its painstaking investigations, reaches the following conclusions:

That the minimum cost of electrification as a means in smoke-abatement would be....................	$178,127,230
That the more probable cost, due to the necessity for improvements and rearrangements, which would be precipitated by electrification, would be..........	$274,440,630
That the least net annual operating deficit produced by electrification would be......................	$14,609,743

That Chicago, under the state constitution, cannot aid in meeting this expense.

That an arbitrary or tax on terminal traffic to support the capital for electrification would constitute a burden upon the business interests of Chicago.

That the cost would be so heavy that no court would uphold an electrification ordinance.

That the Chicago electrification would equal the combined electrifications of the whole world, would involve problems never heretofore met, and would be the first ever undertaken for air betterment where terminals were adequate from an operating viewpoint.

That before the steam locomotive is eliminated pollution must first be reduced to a minimum from the three more damaging services, high-pressure steam plants, metallurgical and other manufacturing furnaces and domestic fires.

That the steam locomotive stands third among smoke-producing services, using but 12 per cent of the fuel consumed, and that its elimination would reduce the gaseous pollution of the air only 5 per cent and the solid pollution less than 4 per cent.

That electrification, long-distance transmission being inapplicable, would add power-house smoke in quantities sufficient to offset much of the gain through elimination of locomotive smoke.

That suburban passenger services, such as those of the Illinois Central and other roads, produce but 1.54 per cent of the total visible smoke, and 1.97 per cent of all the dust and cinders.

That electrification would involve at least 3,476.4 miles of track.

That electrification would subtract only 1,291,282 tons of coal from the total of 21,208,886 tons now consumed annually in the city.

That all smoke regulation in Chicago and elsewhere has erred in confining itself to the visible aspects of smoke, whereas the really harmful factors are the invisible gases and the solids of combustion, sulphurous gas and mineral dust in particular.

That, despite the fact that Chicago burns more coal annually than any other large city—eight tons per capita as against four for Manchester and one and one-half for Berlin—its air is better than that of most large cities.

That the Loop is the smokiest district, with the stock yards and South Chicago a close second and third.

That, in Chicago air, the products of combustion constitute only two-thirds the total pollution, the other third being due to avoidable and unavoidable dirt from the general activities of the city and from poor municipal housekeeping.

Practicability of Electrification.

As regards the financial practicability of electrification the committee submits these findings:

"The complete electrification of the railroad terminals of Chicago as a betterment to be brought about by the railroads through the investment of free capital is, under present-day conditions, financially impracticable.

"The financial practicability, under present-day conditions, of electrification as it might be applied to individual roads or to a single service of individual roads, is a matter which has not been investigated by the committee and concerning which no opinion is expressed.

"The credit of the individual railroads, the properties of which make up the Chicago railroad terminals, differs greatly. Some have high credit and could secure funds for almost any project which their managements might care to propose; others must prove the profitable character of a particular project before underwriters would consider the placement of their securities; others would find it difficult to borrow on reasonable terms even if the particular project for which the funds are sought promises some return; and still others are in the hands of receivers, their administrative function being performed by the courts. These facts cannot be overlooked in estimating what portion of the potential credit of the railroads is available for the purpose of electrification.

"Certain railroads making up the Chicago terminals operate entirely within the prescribed zone, while for others the great predominance of traffic lies outside the terminal limits. There is more to this contrast than is implied by the fact that some of the roads involved are switching roads while others are long-haul freight and passenger roads. Complete electrification, from a financial point of view, would affect but a relatively small part of the fixed investments of some roads, while for others it would require practically the rebuilding of the property.

"Electrification is a matter which may present greater advantages in connection with certain classes of service than with other classes; for example, the electrification of a railroad having a large suburban business would be more effective in developing opinion favorable to the railroad concerned than the electrification of a road the activities of which are wholly those of freight switching yards. A few only depend upon passenger traffic within the city limits for any considerable amount of their revenue. A larger number derive passenger revenue within the terminals from the movement of through passengers only; while other roads perform little passenger service or no passenger service at all.

"The extent to which individual railroads have recently made large capital expenditures for terminal improvements, track elevation and enlargement of facilities in Chicago, and the extent to which they are committed to further expenditure for these purposes, must have a material bearing on their ability to make expenditures for new projects."

The committee holds that the city might well be expected to share in the burden of electrification, seeing that it would be undertaken for the public benefit, but a perusal of court decisions shows that this is impossible. Moreover, the report points out that it would be impossible for the city, under present constitutional and statutory limitations, at least for some years to come, to raise the necessary funds without the issuance of bonds beyond the authorized limit.

Realizing that many public spirited citizens will not understand its decision, in the light of reports of electrifications in New York and elsewhere, the committee points out the essential differences between electrification at Chicago and those installations that have so far taken place in other cities. Nowhere in the world has a steam railroad been electrified to avoid the pollution of a city's atmosphere. Nowhere has a terminal been electrified when that terminal has been satisfactory from an operating standpoint. No electrification in existence, either in America or abroad, is comparable, in scope and diversity of service, with that involved in the electrification of the Chicago terminals. A wide gap exists between that which has been accomplished and that which would have to be done before local electrification would become a success.

"Some of the electrifications that have been most widely heralded as such were in fact only a subordinate, though necessary part of a greater scheme for terminal enlargement. The New York Central, the New York, New Haven & Hartford, and the Pennsylvania electrifications are not alone projects of electrification; primarily they are an essential detail of a new tunnel entry into the heart of New York City. These projects must necessarily stand upon a different basis than the Chicago proposal, where physical conditions absolutely requiring electrification are lacking and where physical conditions and the nature of the traffic would make electrification extremely difficult."

The committee finds that elsewhere steam roads have been electrified for these reasons:

"(1) Electrification has most frequently been employed in operating suburban passenger service.

"(2) It has been used for all passenger service in connection with the intensive development of great passenger terminals where underground operation has been involved.

"(3) It has been used for both freight and passenger operation in tunnels.

"(4) It has been applied to sections of through lines of route to improve operation of both freight and passenger service on difficult grades.

"(5) It has been applied to sections of through route lines in anticipation of operating economies through the utilization of water or other relatively inexpensive centralized power.

"(6) It has been employed by a single railroad in this country in the operation of three switching yards, the work of which must still be regarded as being in an experimental stage."

Notwithstanding the engineering difficulties that would have to be overcome in electrifying the terminals, the committee believes that these difficulties can be surmounted. Its work leads it to the conclusion that the only feasible means of electrification will be by the overhead contact system or trolley. Great obstacles exist to the installation of any system, but it is believed the trolley wire more nearly meets all demands than the third rail. The committee states its conclusions as follows:

"(1) A limited mileage of track in Chicago (approximately 1 per cent of the total) cannot be equipped with any system of contact. The electrification of this not technically feasible.

"(2) While the third-rail system of contact might be extensively used in Chicago, there are, at intervals throughout a considerable percentage of the total trackage, conditions which would make difficult the use of this form of contact. The third rail is applied with difficulty wherever special track work abounds, where street and railroad crossings occur at frequent intervals, and in switching yards. In locations where employees must be between or must cross tracks, as in freight yards, it constitutes a physical obstruction which is highly objectionable. For these reasons the third rail is not considered feasible for general use in the Chicago terminals.

"(3) The facts developed show that any form of overhead contact which can be placed high enough above the rail to give the clearance necessary to permit men to ride and perform necessary duties on the tops of freight cars is not objectionable from a technical point of view. The application of an overhead contact system to the terminals of Chicago will, however, require the contact wire to be lowered in many places in order that it may pass under structures presenting minimum clearance. The great number of points at which the contact wire must be lowered will require the installation of many warning devices, or the enforcement of rigid rules governing the presence of trainmen on tops of cars."

Air Pollution.

The study of atmospheric pollution carried on by the committee is said to be by far the most extensive and scientific ever attempted. All the committee's figures, both on smoke and on electrification, are for the year 1912. The total annual per capita consumption of coal in the city limits was 7.7 tons. The average square-mile consumption of coal within the city limits was 10,797 tons for steam locomotives as against 79,436 tons for all other services combined. In the industrial centers and the heavily populated districts the steam locomotive coal consumption and smoke production is small when compared with the total volume for all sources. In outlying districts, where the population is small and where there is no grouping of industries, the steam locomotive sometimes becomes the greatest smoke producer. In only 4 out of the 27 districts in which the area under consideration was divided do steam locomotives use more than half the total fuel consumed, and these districts are sparsely populated and have very limited smoke-producing services other than smoke from residence chimneys.

For the purpose of its investigation the committee considered smoke in the following aspects:

Visible smoke.
Solids in smoke,
Gases in smoke.

Smoke, in each of its phases, was found to have undesirable features. Smoke from each service was found to have a definite relation to the total volume of smoke pollution, both as to quantity and as to particular features of pollution. In order to ascertain which services produced the visible smoke, the solids of smoke and the gases of smoke, and in what proportion, 11,976 observations were made of locomotive smoke, 1,241 high pressure smoke stacks were put under observation, 2,801 low pressure stacks and 280 stacks of metallurgical and other furnaces. As a result it was found that, in the Chicago smoke district, high pressure steam power and heating plants are the principal smoke producers, metallurgical furnaces and other similar manufacturing fires come second, steam locomotives third, and low pressure steam and other heating plants (domestic fires) fourth.

A significant fact disclosed by the researches of the committee is that which emphasizes the relatively great importance of the solid constituents of smoke. Hitherto most discussions concerning smoke, and practically all measures designed to show the extent of atmospheric pollution resulting from it, have dealt only with its cloud effects. It now appears that the cloud effects are of secondary importance, as compared with effects produced by the soot and dust of smoke. The problem of smoke abatement, therefore, as viewed in the light of the committee's disclosure, is not entirely or largely a problem of suppressing visible smoke, but is one of suppressing the shower of soot, dust and cinders constantly falling from a smoke polluted atmosphere.

Smoke arising from solid fuels was found to be never free from such solids. The amount of solids discharged has no direct relation to visibility. A stack may appear smokeless to the eye, it is said, and yet be the source of a heavy discharge of dust. The adoption of anthracite coal or of coke as a fuel, the committee asserts, will serve to make stack discharges invisible but will not eliminate the dust discharge.

High pressure steam stationary power and heating plants rank first among the visible smoke-producing services, being responsible for 44.5 per cent, metallurgical and other similar manufacturing fires rank second with a production of 28.63 per cent and steam locomotives third with a production of 22.06 per cent.

Metallurgical furnaces and other similar manufacturing fires were found guilty of producing 64.26 per cent of all the solids due to combustion, which constitute two-thirds of the total solid pollution of Chicago air. High pressure steam plants were found to rank second, with a production of 19.34 per cent, low pressure steam and other domestic fires third, with 8.6 per cent and steam locomotives fourth, with 7.47 per cent.

RESPONSIBILITY OF EACH SERVICE FOR SMOKE POLLUTION WITHIN CHICAGO, ON PERCENTAGE BASIS

	Visible smoke per cent	Solids of smoke per cent	Total of smoke per cent	Gaseous carbon per cent	Gaseous sulphur per cent
Steam locomotives	22.06	7.47	10.31	10.11	18.22
Steam vessels	0.74	0.33	0.60	0.55	0.45
High pressure steam stationary power and heating plants	44.49	19.34	44.96	40.68	53.70
Low pressure steam and other stationary heating plants	3.93	8.60	23.00	23.06	19.73
Gas and coke plants...	0.15				
Furnaces for metallurgical, manufacturing and other processes..	28.63	64.26	21.13	25.60	7.90

One-third of all air pollution is due to dirt other than that of combustion. These percentages refer to the remaining two-thirds.

High pressure steam plants produced almost half the total gaseous pollution of the air, the exact figure being 44.96 per cent. Low pressure steam and other domestic fires produced 23 per cent, metallurgical and other industrial furnaces 21.13 per cent and steam locomotives 10.31 per cent.

As a result of its investigation into air pollution the committee finds that one-third comes from sources other than combustion. The air is filled with vegetable, animal and mineral matter which rises from the various activities of the city.

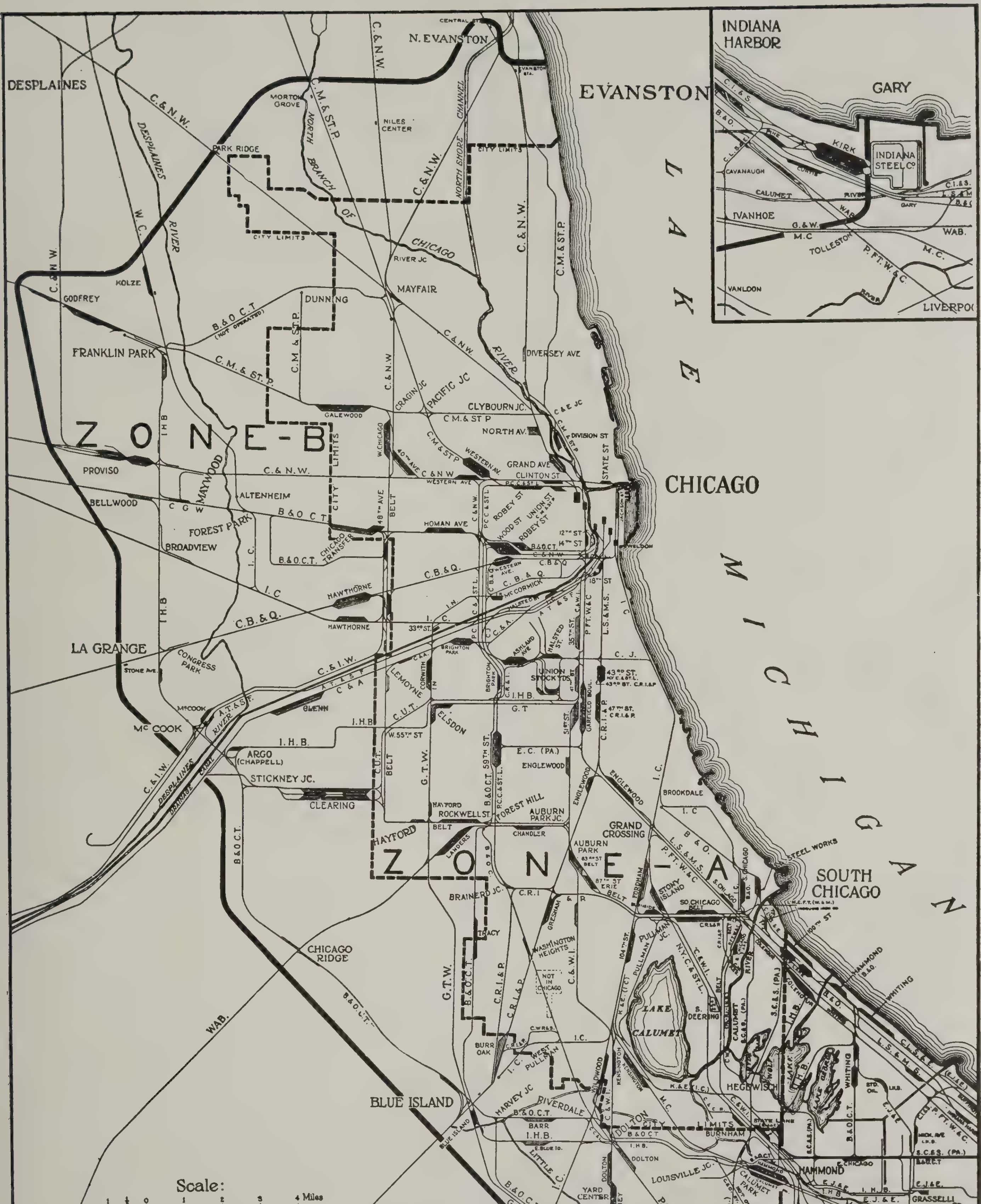
If all the fires in Chicago were stopped, dust and dirt in the atmosphere would remain. Atmospheric pollution cannot be reduced to a minimum through attention to smoke abatement alone. In order to accomplish its reduction attention must be given to all of those processes and activities of the city which give rise to dust or which deal with the collection and disposal of city dirt and waste."

Study of Motive Power Systems.

As a preliminary to its study of electrification the committee made an investigation into other methods of conducting transportation. It had been hoped that some type of self-propelling motor might be found, and the danger, engineering difficulty and expense of electrification be avoided. But this hope was not justified. The systems studied were the internal-combustion motor with mechanical drive, electric drive, compressed-air drive, hydraulic drive, and a direct-connected motor, the compressed-air motor, the hot-water motor and the electric storage-battery motor.

While it was found that progress had been made in adapting the gasolene engine to the requirements of light or special railroad service, the power requirements of heavy and diversified traffic are still beyond the gasolene-driven unit. The Diesel oil-burning marine engine has the power, but neither type is self-starting, an imperative requirement for switching work.

Much had been hoped from the storage battery, but it was found to lack power, and to be too expensive. The internal combustion motors are also regarded



Chicago Terminal Area Included in the Smoke-Abatement Investigation.

as adding a new hazard of operation through their fuel tanks. Compressed-air and hot-water motors were found impractical, but their use is suggested on those sections that cannot be electrified.

"There is available at this time," says the report, "no form of locomotive, carrying its own power, capable of handling the traffic of the Chicago railroad terminals which could be substituted for the steam locomotive, and there is no prospect of the immediate development of any such locomotive."

After studying all electrifications now in existence or planned, both in this country and abroad, the committee finds that of the total of 15 American installations, 9 were undertaken because of operation in subways or tunnels, 1 as an experiment to test out economy in long-distance passenger service, 2 to hold suburban business, 1 was equipped for initial electric operation because of charter requirements, and 2 for the purpose of utilizing water power instead of coal.

Of the foreign electrifications all English lines are classed as suburban. None conducts heavy electric locomotive service and none freight service except in a very minor degree. Practically all electric service is confined to suburban and interurban traffic handled by motor cars. In France the Orleans railway confines its electric locomotive operation to passenger trains through a subway entrance into an underground terminal. It also operates electrically a suburban motor car train service on a line connected with this terminal. The Midi electrification is, in its present stage, experimental only, and for heavy-grade lines where hydro-electric power may be substituted for steam.

In Germany no considerable heavy electric main line traction is as yet in operation; the Dessau-Bitterfeld is a short line and has been operated only in experimental service to test out apparatus and methods. The Magdeburg-Leipzig-Halle line, an important extension of which the Dessau-Bitterfeld line will form a part, when completed will represent the first German trunk line electrification, and the Lauban-Königszelt line will represent a second such electrification. Both are predicted upon the production of cheap centralized power either from very low-grade coal or from hydro-electric plants. While both of these lines will conduct a heavy electric locomotive passenger and freight service, neither will conduct a freight-switching service comparable with that in the Chicago terminals. In Switzerland the Loetschberg line and the Simplon tunnel line were electrified primarily because of tunnel operation; other Swiss electrifications are for light multiple unit train service only. All Swiss electrifications utilize cheap water power instead of the more expensive coal fuel. In Italy the Giovi with its branches is the only road which operates heavy electric service. The secondary lines in foreign countries operate a service which is entirely different from American operation, and resembles our interurban.

The Chicago Problem.

Thirty-eight steam railroads would be involved in the Chicago project, as against 37 for the rest of the world. Of the Chicago roads 25 maintain passenger and freight service and 23 are classed as trunk lines, while 13 perform transfer or switching service only. Eight of the trunk lines have no main tracks within the city limits but operate trains into the Chicago terminals over the tracks of other companies. Twelve railroads operate wholly within the area of investigation.

It was found that the Chicago mileage would be nearly twice that of all other electrically operated mileage in America, and, exclusive of foreign light-service lines, would be about 15 per cent greater than all existing electrifications in the world. The committee's plan involves several times as much yard track mileage as do all existing American electrifications. The number of electric locomotives required would be approximately 4 times that of all now in service in America and 2½ times the number in the whole world.

Of switching service, which constitutes 59 per cent of the total locomotive mileage and presents a grave problem in that it has never been attempted electrically on a large scale, it has been ascertained that yard freight-switching services, on the basis of car-miles, is more than 65 times as great as that on all existing electrified steam roads in America.

"No similar service elsewhere is handled electrically in any considerable volume except that on the Giovi railroad of the Italian State Railways and on the New York, New Haven & Hartford in America. The latter operates, in part electrically and in part by steam locomotives, 3 freight yards having in the aggregate 72.7 miles of track, requiring about 90,000 electric locomotive-hours per year and handling about 2,500,000 car-miles per year in switching and transfer service. The freight yard traffic of the Chicago terminals aggregates approximately 3,430,000 locomotive-hours per annum and approximately 164,400,000 car-miles per annum in switching and transfer service."

In its study of air pollution the committee states that even the comparatively small reduction to be expected from electrification is made less significant when it is recollected that substantial progress in recent years has been made in reducing the smoke from locomotives in Chicago. There is every reason to believe also that the process has not yet reached its maximum. The improvement has resulted both from embellishments in locomotive design and from the exercise of greater skill in operation.

"When, therefore, the fact is set forth that electrification will serve to reduce the amount of visible smoke entering the atmosphere of Chicago by 20 per cent, it should not be forgotten that progress in locomotive design and practice, without electrification, has operated and will continue to operate to bring about a reduction which, if smaller than that to be effected through electrification, is nevertheless material; and when emphasis is given the fact that electrification will serve to reduce the amount of the solid constituents of smoke and the gaseous products of combustion, entering the atmosphere of Chicago, by 5 per cent, it should not be forgotten that progress in locomotive design and operation can very likely be depended upon to bring about an equal reduction."

"The electric operation of Chicago's railroad terminals must depend upon the existence and operation of a steam-driven electric generating station. The conclusion has been reached that a single power-station, located near the south branch of the Chicago river in the vicinity of Ashland avenue, would satisfactorily meet all requirements. The load center, under the plan of electrification as already defined, falls within the limits of the Union Stock Yards. The location indicated is not far from this point and is such as satisfies other requirements of the problem."

The committee believes that the highest degree of efficiency in electrification can only be secured by joint procedure by all the roads. "It is inconceivable that the different railroads will undertake such a work independently. It may be argued that a course necessary in the case of one railroad may prove quite unnecessary in the case of another, and yet the fullest measure of technical success in the electrification can only be secured when individual interests and preferences are subordinate to the requirements of a general plan."

The committee's plan contemplates the electrification of all track within the city limits and the conclusion of electrified trackage on each railroad as close outside the city limits as is practical. The mileage involved by this conception may be summarized as follows:

	Miles.
1. Main track	1,475.59
2. Yard track	1,456.64
3. Industrial track, owned by railroads	277.19
4. Industrial track, railroad repair track and shop track so located in streets at grade, in buildings or under structures employed in industrial processes as to require some type of self propelling motor	37.26
Total	3,476.40

While in general the committee decided to terminate electrification at the first convenient point outside the city limits, this could not be accomplished on certain roads which conduct a suburban passenger service. It would be impracticable to operate these frequent suburban trains part way by electricity and part way by steam.

Choice of System.

As yet no system of electric traction has been developed which can be accepted as standard for all conditions on all railroads. If it were decided to proceed at once with the electrification of the Chicago terminals, it would be difficult for any group of men to choose a system which would not be criticized by other men as able as those upon whom the choice of the system developed.

The system selected for Chicago must be suitable not only for passenger terminals and through line work, but also for yard switching and transfer work. It must be applicable to the requirements of railroads having a heavy suburban traffic, and also to those roads conducting freight-yard and switching service. It must not only be satisfactory in its application to the terminal portion of a trunk line railroad, but it must lend itself to an indefinite extension of the limits of electrification over other and adjoining portions of the road. Obviously, the project must be regarded as too important to permit of the introduction of methods in any way questionable, or of a type of construction of untried value. Furthermore, it is not permissible to consider any methods which might serve to tide over a temporary condition anticipating the later selection of a permanent and stable system.

After obtaining complete engineering data on these three systems, the committee selected the third as cheapest and most desirable:

1—Third rail contact, direct current at 600 volts.
2—Overhead contact, direct current at 2,400 volts.
3—Overhead contact, single-phase current at 11,000 volts.

The third-rail system was given up as the least practical of the three because of the difficulties to be met. Not only would the presence of the third rail be a danger to employees in the yards and make necessary a large amount of reconstruction, but there would be trouble in operating trains, owing to the large number of gaps in the third rail due to switches, street intersection and other such obstructions. It is estimated by the committee that a total of about 75 miles of track in Chicago could not be equipped by the third-rail system. Another objection to the third rail is the fact that except in very unusual sleet storms, service through the trolley wire would not be interrupted, whereas both sleet and drifting snow furnish a serious problem with the third rail. The rail is also a danger to property and life in case of wreck.

The difficulties of trolley installation would also be great, but less, it is believed, than those attending the use of the third rail. The great trouble found is with low bridges and other structures over the tracks. A sufficient clearance to permit employees to ride on top of cars cannot be obtained throughout the Chicago terminals.

The adoption of the overhead contact (trolley) system would permit the use of either a high-voltage direct current or an alternating current of much higher voltage. The use of the first would result in damage to property by electrolysis. The use of the second would "kill" telephone and telegraph wires adjacent to the tracks, through inductive interference. Both conditions could be remedied, though with difficulty and at considerable expense.

The committee finds that it would make no practical difference whether the roads manufactured their own electric power or purchased it from public service corporations. Electricity would, it is concluded, neither increase nor decrease, the dangers of operation. Added dangers would be introduced, but compensating safety in other directions would offset these.

The committee has made an effort to arrive at the incidental advantages that would accrue to the railroads through electrification. The change would give some increased capacity in existing trackage and terminals. In locations where operation under present-day conditions is congested, it would give relief, and in locations where there is at present no congestion, electrification would constitute, in effect, an enlargement of existing facilities and hence would postpone the day when additional facilities would be required.

Electrification would contribute to increased celerity and reliability in train movement. It would open the way to more intensive use of railroad property, both in this manner and by making double-decked freight and passenger terminal stations possible. It would also make possible the erection of buildings over tracks, but this value is regarded as speculative and, as a present-day asset, small. Electrification would give the roads an asset in the use of electric service beyond that required for trains. It would benefit the roads through the increased convenience and comfort of passengers and would give the roads whatever advantage accrued, through the lessening of smoke.

Cost of Electrification.

In arriving at the cost of electrification, the committee based its work on 1912 operation, extended to meet conditions if electrification were to begin in 1916 and be completed in 1922. The following accounting statement shows why the committee holds that electrification is financially impossible. The deficit on the outlay of $178,127,230 would be too great:

I. ANNUAL CHARGES:		
1. Interest	$8,906,362	
2. Depreciation	7,808,278	
3. Replacement of dissipated assets	231,796	
4. Indeterminate charges		
Total charges		$16,946,436
II. ANNUAL REVENUES:		
1. Increase in net revenues	$2,336,693	
2. Indeterminate benefits		
Total credits		$2,336,693
Balance, annual deficit on inventment		$14,609,743

The investigations show that electrified operation for all the railroads taken together and disregarding depreciation and interest would result in a decrease in operating expenses. Under steam operation, those accounts that would be affected one way or the other by electrification show a total of $10,934,064. Under operation by the 600-volt direct-current third-rail system, the total would be $8,442,298, with the 2,400-volt direct-current system it would be $7,355,771 and with the 11,000-volt alternating-current system it would be $7,140,495. The installation of these three systems would result in a saving in operating expenses respectively of $2,491,766, $3,578,293 and $3,793,569.

This saving, however, is in part nullified by new expenses due to the operation of stations that would have to be established at the end of electrified tracks to provide for a transfer of trains from electric to steam locomotives, and also by the waste and consequent loss due to operating over shortened steam railroad divisions, which have surrendered part of their mileage to make the new terminal electric divisions. The engineers' estimates place the added expense under the first item at $1,546,113 and the added expense under the second at $450,000. This would leave the net saving in operating expenses, to follow electrification, at $495,653 for the third-rail system, $1,582,180 for the direct-current trolley system and $1,797,456 for the alternating-current trolley system.

Following the work of the committee, a number of the Chicago railroads have made a study of the cost which would be imposed upon them in excess of those set forth by the committee. Eight of these railroads have filed with the committee the results of their investigations. The reports thus submitted have been analyzed with results which are set forth as follows:

ESTIMATES OF INDETERMINATE COSTS OF EIGHT RAILROADS

1. Cost due to an extension of the mileage of electrification over that provided by the committee's estimates	$20,872,500
2. Precipitated costs principally for track elevation	29,198,400
3. Total cost to the eight railroad corporations in excess of that necessary to electrification under the plan of the committee	50,070,900
4. The committee's estimate of the cost of electrification for the eight railroads	92,599,908
5. The excess costs, including costs due to extension of the plan and precipitated costs, in per cent of those which are covered by the committee's estimates	54.07 per cent

The committee's estimates of the net cost of electrification for all the roads of Chicago totals $178,127,230. Therefore, carrying forward the same ratio, the committee finds that the total added and precipitated costs for all the railroads would amount to $96,313,400.

Upon this basis, the total capital requirement imposed by electrification would be:

That incident to the development of a minimum plan as estimated by the committee	$178,127,230
That required to cover precipitated costs and costs due to extension of plan	96,313,400
Total	$274,440,630

For example, in fixing the limits to be observed by the Chicago, Burlington & Quincy, the committee has specified complete electrification to Hawthorne, 6.8 miles, and partial electrification to provide for suburban service only to Downers Grove, 21.3 miles from the city terminal. In reviewing the work of the committee, the officers of this road conclude that if they were required to electrify it would be necessary to provide for the electric operation of freight service to Eola, 33.4 miles from Chicago, and for suburban service to Aurora, 37.4 miles from the city terminal.

The committee sees an ultimate and large cost due to imitation of Chicago by other cities. "It is apparent also, that Chicago's claim to the benefits of electrification are in no way different from those which might be urged by many other cities with which Chicago railroads connect; that compulsory electrification, if achieved for Chicago, may in due time be secured by all the larger cities of the country. The cost, therefore, of the compulsory electrification of Chicago's terminals would be confiscatory."

WHY CHICAGO RAILROADS CANNOT ELECTRIFY

Electrification would ultimately cost		$274,440,630
The 600-Volt direct current (Third Rail) system, minimum plan, would cost		$197,908,000
The 2,400-volt direct current (Trolley) system, minimum plan, would cost		$191,666,808
The 11,000-volt alternating current (Trolley) system, minimum plan, chosen as the least expensive, would cost, in detail:		
1. Power-station	$10,302,104	
2. Transmission system	1,618,693	
3. Substations	2,024,736	
4. Switching stations	573,073	
5. Contact system	28,141,188	
6. Bridge warnings	1,071,989	
7. Return circuit	4,446,033	
8. Elimination of inductive effects and electrolysis	996,727	
9. Telephone system	272,052	
10. Electric locomotives, multiple-unit equipment, work and inspection equipment	91,703,557	
11. Spare parts	485,343	
12. Changes in overhead structures	834,261	
13. Changes in wire lines	2,028,007	
14. Changes in signal system	6,111,407	
15. Removal and re-establishment of locomotive terminals and new facilities	37,293,746	
	$187,902,916	$187,902,916
Less salvage on equipment usable elsewhere		9,775,686
Net cost of committee's minimum plan		$178,127,230
Plus added costs due to betterments, improvements and changes precipitated by electrification		96,313,400
Estimated total final cost		$274,440,630
Annual charges on inventment of $187,902,916		$ 16,946,436
Annual saving through decreased costs of operation		$ 2,336,693
Annual deficit		$ 14,609,743

The committee was appointed in March, 1911, and consisted of four members appointed by the mayor, four appointed by the railroads and nine appointed by the Chicago Association of Commerce. The late Horace G. Burt was chief engineer for the committee until May, 1913, and was succeeded by W. F. M. Goss, dean of the Engineering Department, University of Illinois. The report was submitted to the association at a dinner on Wednesday evening, December 1.

Lighting of Classification Yard

New York Central Railroad Air Line Junction, Ohio

The Air Line Junction yards of the New York Central were laid out in 1912 and were put in operation shortly afterward. Classification of cars is carried on in these yards both night and day, but until September, 1915, no provision was made for artificial lighting. Every car rider carried a lantern and had to depend on this and the switch lights for safeguarding himself and the cars which he handled. As a result, night work was slow and meant many disabled cars.

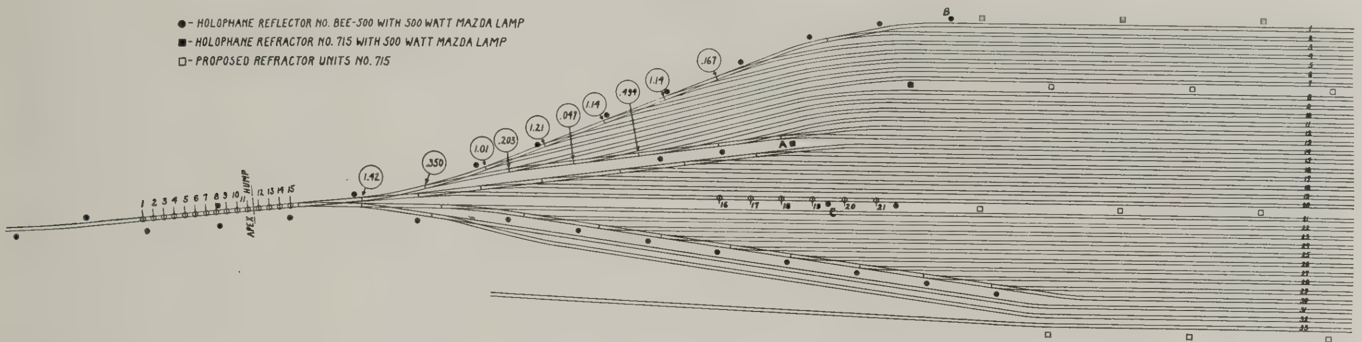

● - HOLOPHANE REFLECTOR NO. BEE-500 WITH 500 WATT MAZDA LAMP
■ - HOLOPHANE REFRACTOR NO. 715 WITH 500 WATT MAZDA LAMP
□ - PROPOSED REFRACTOR UNITS NO. 715
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
HUMP
APEX
1.42
.350
1.01
.203
1.21
.047
1.14
.434
1.14
.167
A
B
C
16 17 18 19 20 21

Fig. 1. New York Central Classification Yards at Air Line Junction. Showing Location of Lighting Units, Photometer Stations and Horizontal Foot Candle Intensites on the Various Switches Indicated.

Fig. 2. Night View of the Yard from the Crown of the Hump.

Installation.

A trial installation has been made, using suitable lighting units located as shown in Fig. 1. This figure shows only a portion of the yard, but is typical of the rest.

On the hump track and ladder tracks, units are spaced approximately 100 ft. apart. In the body of yard the spacing of units will be approximately 200 ft. apart. (The refractor units in the body of the yard have not yet been installed.) The mounting height of all units is 35 ft. above the ground.

The lighting units are mounted at the end of cross arms at the top of 40 ft. wooden poles set five ft. in the ground. A disconnecting hanger is used which permits the units to be lowered to the ground for cleaning and for the replacing of lamps.

Deep bowl porcelain enameled reflectors (Holophane reflector No. BEE-500 and holder No. 672) with 500 watt Mazda C lamps and suitable holders were used along the hump and ladder tracks. This unit, together with photometric curve, is shown in Fig. 4. The object in using deep bowl reflectors is to cover the lamps so that the brilliant filament will not shine in the eyes of trainmen. In order to operate with the greatest rapidity and safety, it is necessary that the engineer on the pushing engine be able to see distinctly signals at the apex of the hump, and that the riders and switchmen be able to see every switch on the ladder tracks, from the apex of the hump or from any point along the ladder tracks. The use of deep bowl reflectors means a closer spacing of units than could otherwise be used, but the elimination of glare more than compensates for this.

In the body of the yard, the absence of glare is not so important as it is on the hump and ladder tracks. Therefore, a unit which would permit of wide spacing of units was decided upon. The unit used is Holophane prismatic refractor No. 715 with 500 watt Mazda C lamps, drawing and photometric curve of which are shown in Fig. 3. Due to the prismatic redirecting prisms in this unit it is possible to obtain a strong circle of light at a wide angle. It is this feature which makes wide spacing of units possible with any degree of uniformity in the lighting.

Tests.

In order to have a permanent record of the performance of this installation, a series of illumination readings was made. On account of inability to keep the yard out of operation for any length of time it was not possible to make as many readings as were desired, but enough were obtained to give some indication of conditions.

Apex of Hump.—The principal requirements on the hump are illumination of the front end of the car on approaching the apex and illumination of the other end while leaving the apex. It is also necessary to light the side of the car while passing the apex. Table I shows the foot candle values obtained on the ends of the cars, while Table II gives the same data for the side of the car. At station 7 (Fig. 1) the illumination reaches a maximum. This is where the cutter checks his list against the car markings and where the rider mounts the car.

Ladder Tracks.—The most important requirement along the ladder tracks is to have good light on every switch, so that there will be no mistake in switching cars and so that the switchman can see how things stand, from a considerable distance. Where the switches are hand operated, it is necessary for the switchman to be able to read his list of cars rapidly and without the aid of a lantern.

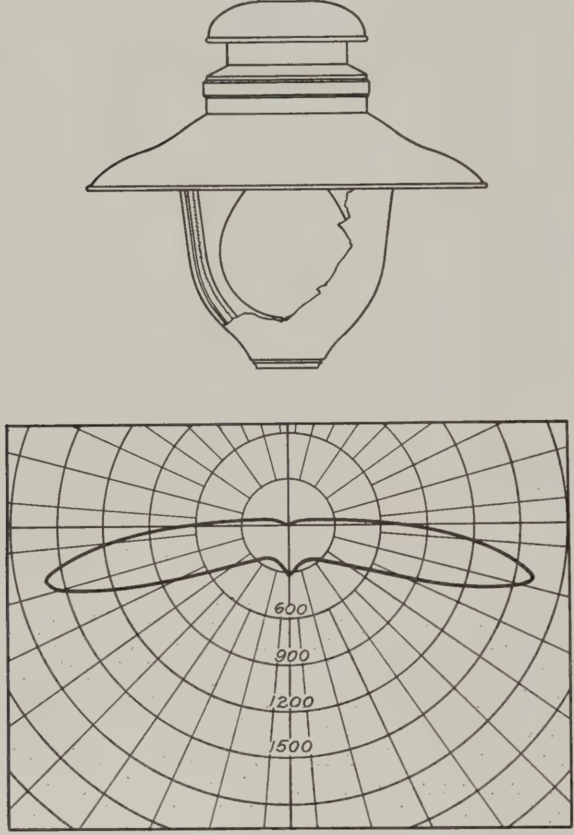


Fig. 3. Holophane Prismatic Refractor No. 715 for 500-Watt Mazda C Lamp.

Body of Yard.—Here the most difficult requirement is to light the end of a car no matter where it is standing, so that there will be no danger of a rider misjudging his distance and bringing his car into the standing one too roughly. The proper lighting of the ends of standing cars also permits more efficient handling of cars, as the rider can coast more rapidly without fear of failing to stop in time. In addition to the ends of the cars, the tops should be lighted to permit the rider to pass from one to another. Any vacant tracks should be lighted well enough to disclose any obstructions. Table III gives the foot candles obtained on the end of a car when in the body of the yard. Tests at stations 16, 17 and 18 were made with deep bowl reflectors and it is seen that at station 18 there was no light received at the top of the car. Tests at stations 19, 20 and 21 were made with a refractor placed at point A and deep bowl reflector at C turned off. The use of the refractor improves conditions considerably, and if it had been possible to try out additional refractor units in conjunction with this one, even more marked improvement would undoubtedly have been found.

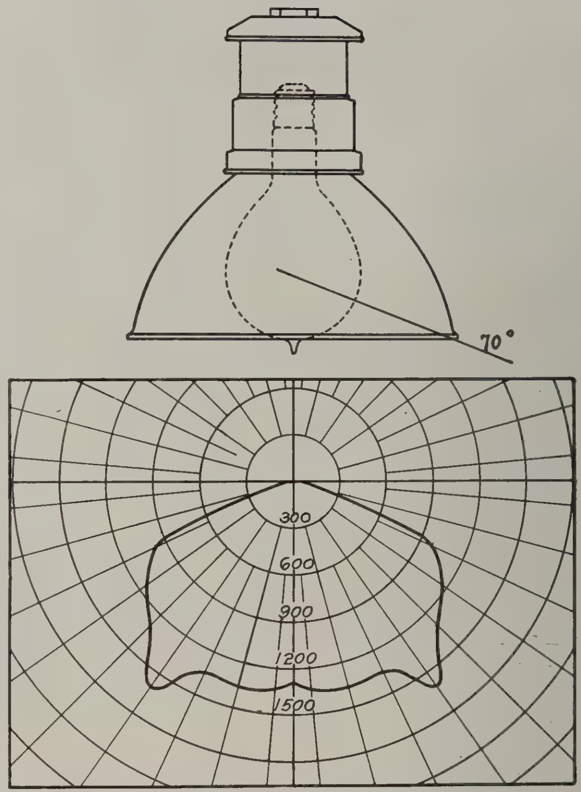


Fig. 4. Deep Bowl Holophane Reflector No. BEE-500 and Holder No. 672 with Photometric Curve for 500-Watt Mazda C Lamp.

TABLE I.

Illumination in Foot Candles on End of Car Nearest Apex of Hump, at Points F and G. (See Fig. 6.)

Station (See Fig. 1)	Foot Candle Intensity on End of Car. Point F	Point G
1	0.139	0.162
2	0.033	0.035
3	0.048	0.050
4	0.104	0.158
5	0.377	0.364
6	0.887	0.889
7	1.612	1.696
8	0.196	0.243
9	0.030	0.031
10	0.826	0.752
11	0.167	0.130
12	0.068	0.053
13	0.041	0.034
14	0.018	0.023
15	0.454	0.401

TABLE II.

Illumination in Foot Candles on Side of Car at Points A and C (See Fig. 6.) When Passing Over Hump.

Station (See Fig. 1)	Foot Candle Intensity on Side of Car. Point A	Point C
1	0.616	0.850
2	0.461	0.515
3	0.181	0.174
4	0.082	0.052
5	0.082	0.068
6	0.167	0.186
7	0.517	0.573
8	0.956	1.220
9	0.531	0.664

TABLE III.

Illumination on End of Car at Points M and P (See Fig. 6.) When Standing in Yard. Note—Unit A was not burning for tests at Stations 16, 17 and 18. Unit C was not burning for tests at Station 19, 20 and 21.

Station (See Fig. 1)	Foot Candle Intensity on End of Car. Point M	Point P
16	0.026	0.000
17	0.038	0.30
18	0.027	0.026
19	0.059	0.049
20	0.037	0.034
21	0.031	0.026

Conclusion.

Illumination tests at the present time are an inadequate measure of a lighting installation of this nature. After more study has been given the subject a comprehensive method of test may be devised which will take into account all the peculiar requirements to be met in different parts of the yard. An attempt has been made along these lines in the present tests, but the results are incomplete and not extensive enough to thoroughly cover the subject. The most conclusive proof of the success of this installation is the general approval of the men in actual charge of the handling of cars, and the fact that all the cars sent them are handled smoothly and with dispatch. The efficiency of the yard will be still further increased when the installation is completed by placing refractors through the body of the yard, as indicated in Fig. 1. To obtain complete satisfaction there should be an additional row of units between tracks 13 and 14 and between tracks 26 and 27, but owing to the original lay-out of the yard there is no space for these.

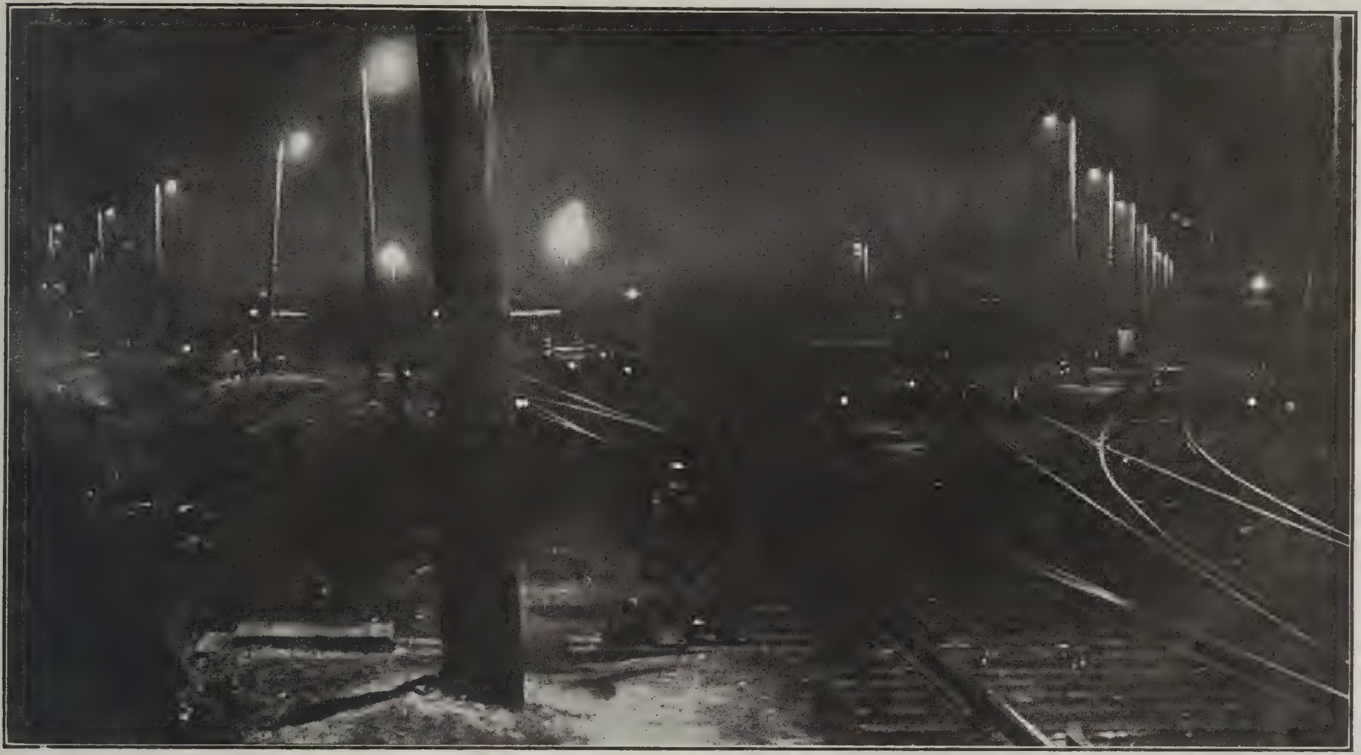


Fig. 5. Night View of the Yard from the Hump.

Figs. 2 and 5 show in some degree the appearance of the portion of the yard at present lighted. It will be noticed that the apex of the hump, where the cutting and checking of cars is done, is particularly well lighted and that every switch on the ladder tracks stands out distinctly. The absence of glare will also be noticed, a distinct contrast being evident between the deep bowl reflectors in the foreground and the two refractors in the distance.

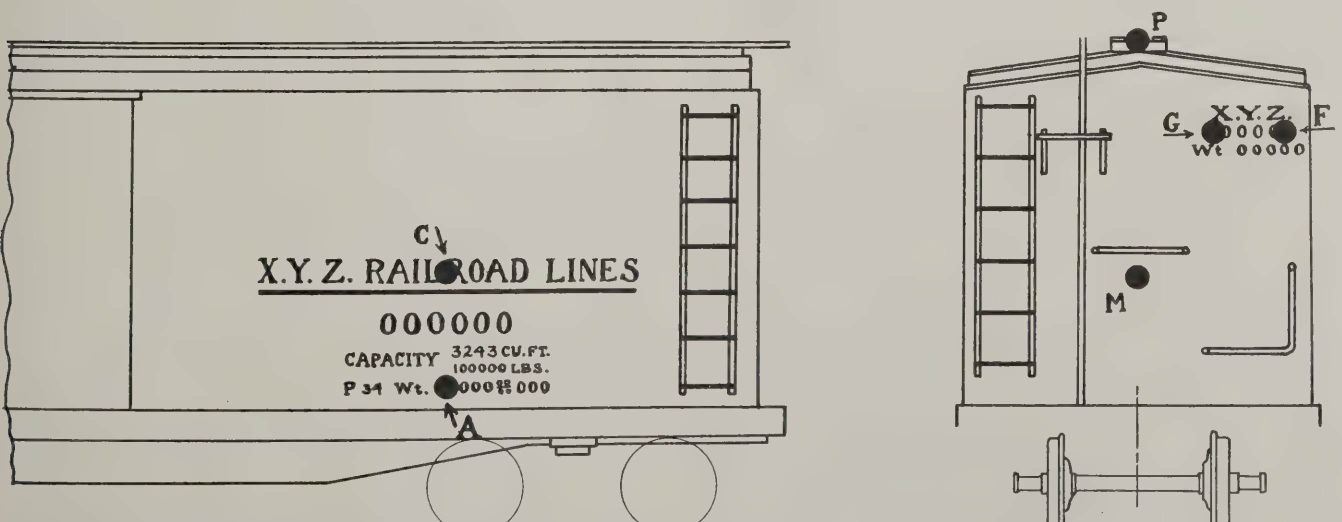


Fig. 6. Side and End View of Box Car Showing Illumination Test Points Mentioned in Tables I, II and III.

Electric Car Lighting

E. S. M. Macnab

There is a strong demand for electric light on passenger cars from standpoints both of safety and comfort. The possibility of fire in case of wreck is practically nil when electric light is used. Taking the question of comfort, the chief advantage is the application of berth lights in sleeping cars, together with the use of fans in dining and parlor cars, in addition to which may be added a cooler light devoid of all odor which comes from gas lighting, and the ability to place lights in any position in a car where they may be most convenient.

The number of electric-lighted cars in service in Canada and on certain roads in United States in 1911 and 1914 is shown in the table. It is apparent that there is a strong demand for electric lighting in passenger cars, and also that the railways are meeting it in a liberal spirit.

Table Showing Increase in Electrically Lighted Cars, 1911 to 1914.

Railway Company	Number of cars equipped 1911	Number of cars equipped 1914	Increase in cars equipped
Canadian Pacific	68	359	291
Grand Trunk	34	164	130
Grand Trunk Pacific	..	72	72
Canadian Northern	14	226	212
Total in Canada	116	821	705
Pullman Company			
Pennsylvania Lines East.	902	1,924	1,022
Pennsylvania Lines West	516	714	198
N. Y. C. & H. R.	202	1,007	855
N. Y., N. H. & H.	350	410	50
Lehigh Valley	81	384	303
Great Northern	480	650	190

The electric lighting of passenger cars may be devided into three main classes—straight storage, head end and axle systems.

The straight storage, while it is the simplest system, requires that cars lay over in terminal yards from six to ten hours for recharging batteries. This system is, therefore, out of the question for transcontinental services, as any road which has not a surplus of rolling stock cannot afford to hold its trains in the terminal yards for sufficient time to charge the batteries. Another disadvantage is the heavy capital cost of installing the necessary battery-charging facilities at all terminals.

The chief disadvantage of the head end system is the want of flexibility, and this is felt where trains have to be remarshaled at junctions and cars switched off on branch lines. This leads to the necessity of equipping a large proportion of the cars on every train with batteries, increasing the capital and maintenance costs. Another disadvantage is the high steam consumption of the turbine.

The axle system, which is the most extensively used, comprises a generator driven by a belt from the axle and a set of storage batteries which supply current to the lamps when the train is at rest. As this equipment is applied to each car, it follows that it is an individual unit and can be transferred to any line in any class of service without any adjustment of the apparatus being necessary.

Organization.

The question of organization is the chief factor to be determined if efficient results are to be obtained. To illustrate the capital expenditure and maintenance costs, take a road having 400 electric-lighted cars. As each installation will cost, say, $1,500, we have a total expenditure of $600,000, of which $800 per car, or a total of $320,000, is liable to be permanently destroyed through want of attention. Assuming a total of 400 cars at a maintenance cost of $12.00 per car per month, we have a maintenance cost of $4,800 per month, or $57,600 per annum. If by better handling we save one lamp per car per month, we effect a saving of $180 per month, or $2,160 per annum. Again, a conservative estimate will place the life of a battery set at five years. Assuming we have two twelve cell batteries per equipment and that we increase their life by one year; taking the cost of the batteries as $630, we have:

Depreciation at 5 years	$125 per annum
Depreciation at 6 years	105 per annum
Saving per car	$21 per annum

Multiply by 400 cars and we have $8,400 per annum saved.

Again, take the question of belt life. A saving of one belt per car per annum will approximate $5 per car per annum, or $2,000 per annum on four hundred cars.

Summarizing, we have:

Saving of one lamp per car per month	$2,160 per annum
Extending life of batteries by one year	8,400
Saving one belt per car per annum	2,000
	$12,560 per annum

These figures show what may be saved or lost through properly handling or neglect of the equipments, setting aside the discomfort caused to passengers due to light failures.

There is a considerable difference in the methods of organizing this work on the railroads in the United States. In some cases the forces are controlled directly by a chief electrician, who reports to the master car builder. On some roads the chief electrician acts in an advisory capacity to the master car builder, the forces being controlled by the car foreman; on others the electrical engineer through his assistants directly controls the terminal electricians. On one road in the United States the electricians are carried on the car foreman's pay roll, and are responsible to him as far as matters of discipline are concerned, but are responsible to the chief electrician for all technical work. As a general rule, the closer the chief electrician or electrical engineer is to the inspection forces, the more efficient the organization.

The chief electrical engineer should supervise the preparation of the specifications and wiring diagrams for all new rolling stock and see that they are lived

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* Abstract of a paper read before the Canadian Railway Club on October 12, 1915.

up to by the car builders. This is important, as all equipments, as far as possible, should be installed to certain standards; the various conduit runs should be inspected to see that new wires may be drawn in at any time without tearing down the interior finish of the car. The quality of the conduit and wires should also be closely watched, as these items will affect the cost of maintenance in later years.

The generator suspension should be closely checked with the object of providing for sufficient belt clearance; it will well repay any railway to give this point due consideration, as it is no idle statement that fully half the light failures and lost belts are due to insufficient clearance.

The type and location of fixtures should also receive attention. As far as possible, standard types should be used, involving the minimum number of classes of glassware; as a rule, clear, unshaded lamps should not be used, as they are liable to cause eye strain. It is also advisable to standardize one size of lamp, which, on a large system, must be carried in the stores at all terminals.

The introduction of 50-watt gas-filled lamps which have recently been placed on the market should considerably reduce the number of fixtures and also simplify their construction.

Maintenance of Equipment.

To maintain the equipments in a proper state of efficiency periodical inspection and overhaul are necessary, and any neglect of either will result in a heavy expenditure for renewals.

Each equipment should receive a thorough overhaul once a year, when the generator should be removed from the car, taken apart, cleaned and worn parts renewed, and on being rebuilt should be tested on a special test frame. The batteries should also be taken to the battery house, where each cell should be opened up, the cell box washed out under a spray, all bent plates straightened, and damaged separators renewed. The battery should then be reconnected in the shop and properly charged, when a discharge test should be taken and its capacity noted. After recharging, the specific gravity of the electrolyte should be adjusted and the cell and battery boxes painted. The set is then fit to be replaced on the car. If the car is fitted with lamp and generator regulators they should be reset, the carbons being specially examined. Considerable difference of opinion exists as to whether this overhaul should be carried out at the terminal yards or at the shops of the company. In favor of the former system it is claimed that, by changing the equipments at the terminals, the overhaul is not dependent on the shopping of the cars, which in some cases is not on the twelve months basis. Also that more interest is taken in the work by the yard staffs than by the shop men. The latter method has the advantage of concentrating the work and insuring a standard treatment of each equipment and therefore lends itself to better organization.

Inspection.—A yard force, under the supervision of a chief electrician or foreman, should be located at each terminal where trains originate, and each car arriving should be inspected to see if the equipment is in good working order before leaving on its next trip, and then all necessary running repairs made.

On the Canadian Pacific we find it advisable to give each car in transcontinental service a thorough inspection at Montreal and Vancouver, local cars receiving a similar inspection once a fortnight with a lighter inspection each trip.

At each inspection the height of the acid in the batteries should be noted, and water added, if necessary. Neglect of this will cause sulphating of the plates, decreasing the capacity and life of the batteries.

Yard Facilities.

The modern battery room is equipped with a washing table on which the elments can be inspected and also a compressed air and water spray over which the cell box is cleaned. Benches should also be provided to hold at least six sets of batteries while they are being charged prior to being applied to the cars. Acid tanks for mixing new electrolyte and for holding electrolyte removed from cells while they are being overhauled should be provided, together with a press for straightening plates, also steam-jacketed tanks for boiling the acid out of connections, etc. A still should also be installed if Edison batteries are used.

The generator repair room should be fitted with a bench on which a generator may be conveniently dismantled and rebuilt. A work-bench with a vise is also necessary, together with lockers and cupboards.

Battery charging facilities should be provided in the battery room and throughout the yard, in order that the batteries on any car may be charged without switching the car to any special point.

The Canadian Pacific practice is to run a circuit between each alternate pair of tracks, the wires being carried overhead on poles, the receptacles being placed on the poles about five and one-half feet from the ground, each circuit having five receptacles, connected in series, about eighty feet apart. These circuits run back to a receptacle panel on the switchboard and by means of short flexible jumpers are connected to a number of power receptacles which are connected to the buss-bars through a variable resistance, reverse and overload circuit-breaker and ammeter.

At the Glen yard, Montreal, power for charging batteries is obtained from two 25-kw. motor-generator sets. The switchboard consists of two main direct current generator panels, each equipped with an ammeter showing the total load on each generator. Distribution panels embodying seven circuits are each equipped with 75 ampere overload and reverse-current circuit-breakers, a 100 ampere ammeter, and a 1.9 ohm variable resistance with a carrying capacity of sixty amperes. Each circuit is connected to two power receptacles in series on the receptacle panel. By this arrangement it is possible to regulate the charging current to each set of batteries on a car in any location in the yard.

Records.

A set of records should be kept in the electrical engineer's office showing the details of the equipments on each car (Fig. 1) together with a separate battery record (Figs. 2 and 3). A statement of failures should be prepared each month showing the number of cases of trouble, the type of equipment and batteries and cause of trouble (Fig. 4). From this an efficiency statement is made up showing the number of failures per thousand car miles, also the number of miles per failure (Fig. 5). In this way it is possible to watch the operation of the equipments from month to month.

RECORD OF CAR LIGHTING EQUIPMENT.

CAR—Name or Number................Initials........R. R. Class...........
GENERATOR, Number ....Type ....
Voltage .... Special features ....
GENERATOR PULLEY, face.........Diam..........Dwg..........Patt. No.....
AXLE, diam. at Pulley hub..........Length turned..........Dia. of Wheel.....
Distance from axle center to pulley center..............Dwg...........
AXLE PULLEY, Iron or Steel, Dia......Face......Bore......Length hub.......
Dwg .... Patt No. ....
Belt, kind .... Width .... Length .... Ply ....
Fasteners ....
....
BATTERY, number cells .... Type .... No. of plates ....
Number of boxes .... Dwg. ....
No. LAMPS. 8, C. P. .... 12 C. P. .... 16 C. P. .... Kind ....
No. Fans .... Size .... Make .... Type ....
" .... " .... " .... " ....
WIRING, Diagram ....
WIRED BY .... Date ....
EQUIPMENT INSTALLED BY .... at .... Date ....
EQUIPMENT TESTED BY ....Date ....
DYNAMO RESISTANCE .... Aux. Resistance No. 1 ....
Switch, type ....
FIXTURES, type .... and Card No. ....
Amperes to Lamps, 1-2 lights .... Full lights ....
CAR ENTERED SERVICE ....
MISCELLANEOUS DATA ....

Fig. 1. Form Showing Details of Equipment on Each Car.

BATTERY RECORD CARD

BATTERY No. .... TYPE ....
NEW ....

Date	Applied to Car	Repairs and Material	Cost

Fig. 2. Form for Keeping Record of Each Individual Battery.

CANADIAN PACIFIC RAILWAY COMPANY
RECORD OF BATTERIES CHANGED
Battery No................................

Removed from Car	Date	Applied to Car	Date	Material Used	Cost	Amp. Hrs. Test.	Remarks

Station.......................................**Signed** ....

Fig. 3. Form for Keeping Record of Battery as It is Changed From One Car to Another.

EFFICIENCY RFPORT OF ELECTRIC CAR LIGHTING
STATEMENT OF FAILURES

....Lines Month....................

Date	Car	Type Equipment	Cause of Trouble

Fig. 4. Monthly Statement Showing Details of All Failures.

Accounts.

The determination of the cost of operating the equipment is one of the most important items to be followed up, as without a proper accounting system it is impossible to trace any of the numerous leaks which may occur in the maintenance. Practically every railroad has a different method of keeping accounts and the general system in vogue on the road will determine the method of obtaining the lighting costs. Undoubtedly the most satisfactory method of keeping accounts is one which gives the cost of labor and material of each car per month, from which the cost of the various systems in operation can be ascertained, but this is not always possible.

The chief drawback to this system is that the figures are prepared by the electrical department, who may have difficulty in obtaining the correct prices, etc. On the Canadian Pacific the cost of labor and material at each point is bulked against all the cars, as shown in Fig. 6. The material is then subdivided under the various headings and shown in a separate statement, as per Fig. 7, and from these two a summary, which shows the cost of each item per car per month is compiled, as per Fig. 8. Any increase as shown in the summary can be traced back to the point at which the material was used and an explanation obtained. The summary also shows all foreign charges made against the company, and also those rendered against other companies; these figures are important, as they show whether the interchange inspectors are billing foreign companies for work done and also the rental of the equipments while on foreign lines, which is allowed by the M. C. B. Association at the rate of 75c per equipment per day.

Inspection Reports.

Each car is supplied with two report books (Figs. 9 and 10), which always remain in the switch locker. One of these is filled out in triplicate by the conductor, one copy remaining in the book, one being sent to the superintendent of the S. D. & P. C. department, and the other to the electrical engineer. This report shows any defects which may be noticed by the crew.

EFFICIENCY REPORT OF ELECTRIC CAR LIGHTING
EASTERN LINES

Month ....

Type of Car	Mileage	No. Complaints	No. Complaints per 1000 Car Miles	Remarks
Sleepers...... Observation.. Diners........ Parlor........ Coaches........				
Total				
WESTERN LINES				
Sleepers...... Observation.. Diners........ Parlor........ Coaches......				
Total				
Total for all Cars				

Fig. 5. Efficiency Statement Compiled Each Month, Showing Number of Complaints Per 1,000 Car Miles for Each Class of Car.

The other report is filled out by the terminal electrician in duplicate, showing the condition of equipment on arrival, all repairs made, and if batteries were charged. One copy remains in the book and the other is sent to the electrical engineer. By this means we have two permanent records of the operation of the equipment on each car, which can be traced by either an inspector or terminal electrician at any time, which

STATEMENT "A"

Auditor of Stores and Mechanical Accounts

CANADIAN PACIFIC RAILWAY COMPANY

Cost of Labor and Material for Maintenance of Electric Lighted Cars. *June 1915 Account*

LOCATION	OVERHEAD CHARGES				TOTAL			COST
	Labor Shop Exp	Material Shop Exp.	Material Store Exp.	TOTAL	Labor	Material	Curr. Cons. Chg. Batt.	TOTAL
EASTERN DIVISION								
Glen Yard								
Ottawa								
Toronto Union								
Quebec								
Place Viger								
North Bay								
Chapleau								
St. John								
SHOPS								
West Toronto								
Angus								
Salaries								
TOTAL LINES EAST								
WESTERN LINES								
Fort William								
Moosejaw								
Calgary								
Winnipeg								
Strathcona								
Vancouver								
Revelstoke								
SHOPS								
Winnipeg								
Ogden								
Salaries								
TOTAL LINES WEST								
TOTAL ALL LINES								

Rental Charges from Foreign Lines
Less " " to " "
TOTAL

Fig. 6. Statement Showing Cost of Labor and Material for All Cars at Each Point.

STATEMENT "C"

Auditor of Stores and Mechanicul Accounts

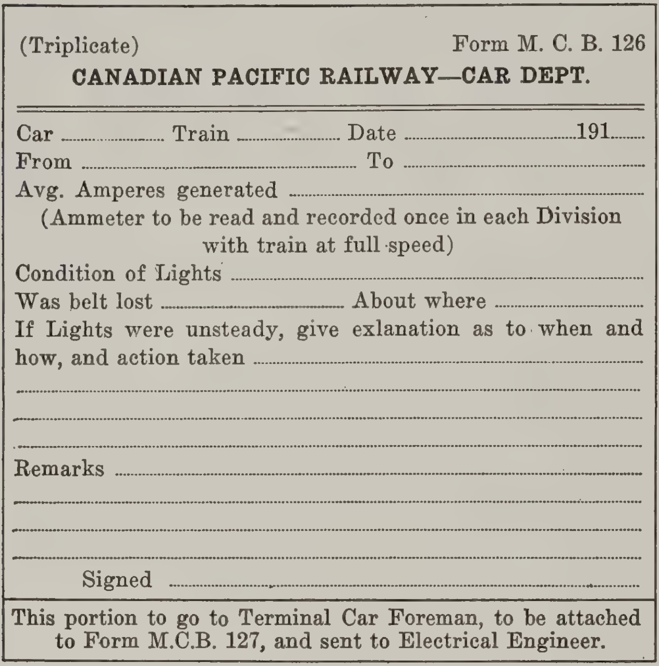
CANADIAN PACIFIC RAILWAY COMPANY

Details of Material, Maintenance of Electric Lighted Cars, Eastern and Western Lines. *June 1915 Account*

LOCATION	Generators	Batteries	Belts	Lamps	Glassware	Bells	Miscellaneous	Extra	Current	Foreign	TOTAL
EASTERN LINE											
Glen Yard											
Ottawa											
Toronto											
Place Viger											
North Bay											
Chapleau											
St. John											
TOTAL LINES EAST											
Angus.											
WESTERN LINES											
Fort William											
Moosejaw											
Calgary											
Winnipeg											
Strathcona											
Revelstoke											
Vancouver											
TOTAL LINES WEST											
TOTAL ALL LINES											

Fig. 7. Statement Showing Detailed Cost of All Material at Each Point.

is considerable assistance to electricians where cars are in transcontinental service and are inspected by several inspectors, as it keeps each posted on the work done by the others. At the same time these forms are filed in the electrical engineer's office and are retained for two months. From these two forms the efficiency and failure statements before mentioned (Figs 4 and 5) are prepared.



(Triplicate) Form M. C. B. 126

CANADIAN PACIFIC RAILWAY—CAR DEPT.

Car .... Train .... Date ....191........

From .... To ....

Avg. Amperes generated ....

(Ammeter to be read and recorded once in each Division with train at full speed)

Condition of Lights ....

Was belt lost .... About where ....

If Lights were unsteady, give exlanation as to when and how, and action taken ....

Remarks ....

Signed ....

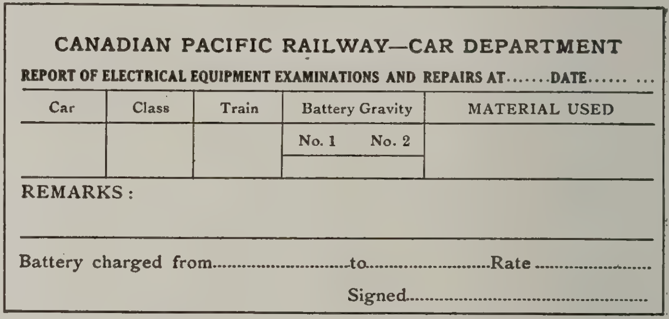
This portion to go to Terminal Car Foreman, to be attached to Form M.C.B. 127, and sent to Electrical Engineer.

Fig. 9. Report Form Located in the Switch Locker and Used by the Train Conductor to Report Any Defects Noticed by Train Crew.

Conservation of Light.

All who are connected in any way with the operation of electric lighted equipment should assist in saving as much light as possible while the cars are in the coach yards, terminals, etc. By all means give the passengers all the light they require, but save the waste. Probably gas lighting is more or less responsible for much of the waste which now prevails, as it is possible to use the gas in the tanks before a train arrives from the yard to receive its passengers, and replenish the tanks in a few minutes, whereas to recharge the batteries of an electric lighted car may take eight or ten hours.

In conclusion I would draw attention to the work which has been accomplished by the Association of Railway Electrical Engineers, who, in conjunction with the train lighting committee of the Master Car Builders' Association and the various manufacturers, have worked out the various standards and specifications which assisted in raising the problem of electric lighting of passenger cars to its present state of practically universal adoption.



CANADIAN PACIFIC RAILWAY—CAR DEPARTMENT

REPORT OF ELECTRICAL EQUIPMENT EXAMINATIONS AND REPAIRS AT........DATE........

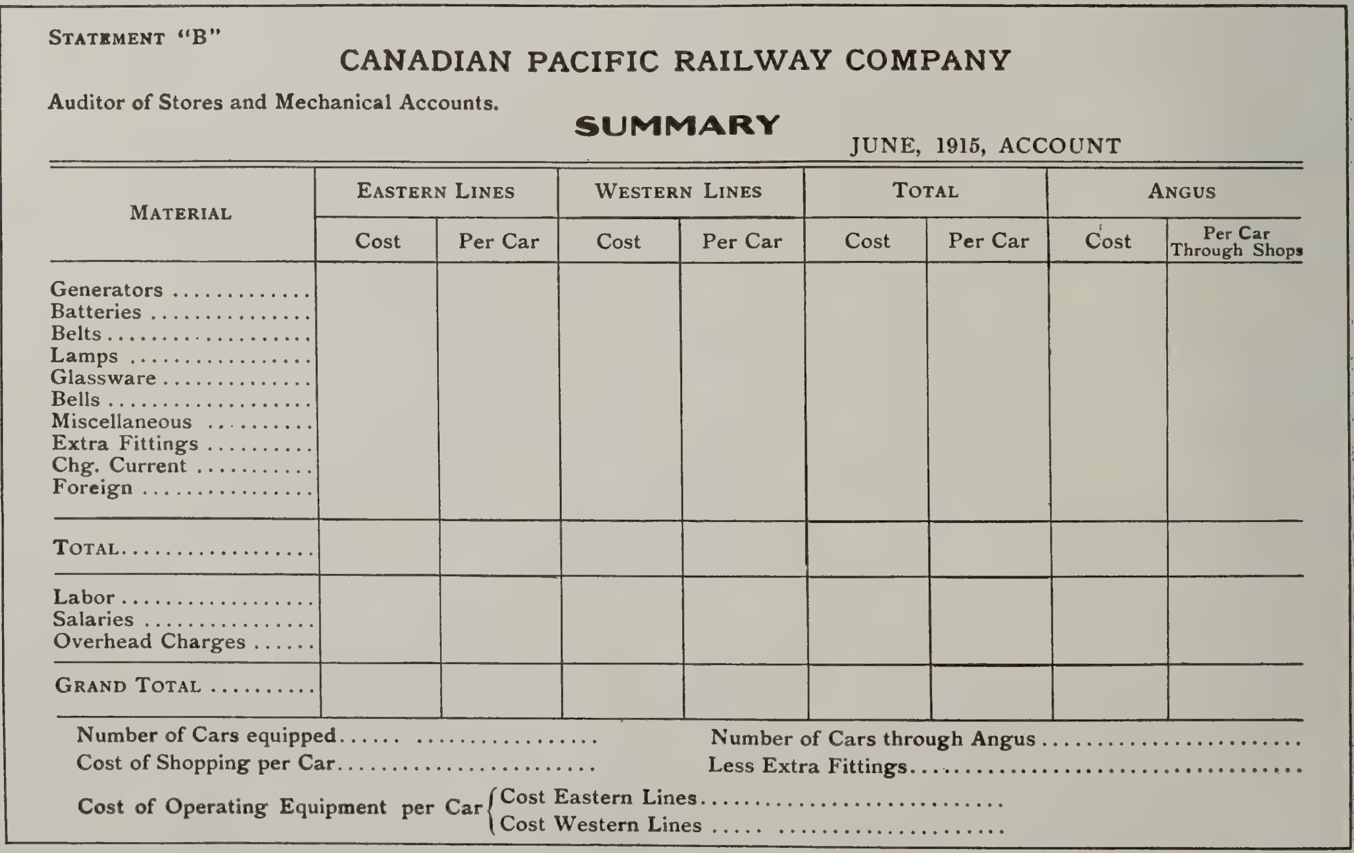
Car	Class	Train	Battery Gravity		MATERIAL USED
			No. 1	No. 2	

REMARKS:

Battery charged from..............to..............Rate..............

Signed..............................

Fig. 10. Report Filled Out by Terminal Electrician Showing Condition of Equipment on Arrival, Repairs Made and Battery Charging, If Any.



STATEMENT "B"

CANADIAN PACIFIC RAILWAY COMPANY

Auditor of Stores and Mechanical Accounts.

SUMMARY

JUNE, 1915, ACCOUNT

MATERIAL	EASTERN LINES		WESTERN LINES		TOTAL		ANGUS	
	Cost	Per Car	Cost	Per Car	Cost	Per Car	Cost	Per Car Through Shops
Generators								
Batteries								
Belts								
Lamps								
Glassware								
Bells								
Miscellaneous								
Extra Fittings								
Chg. Current								
Foreign								
TOTAL								
Labor								
Salaries								
Overhead Charges								
GRAND TOTAL								

Number of Cars equipped.......................... Number of Cars through Angus..........................

Cost of Shopping per Car.......................... Less Extra Fittings..........................

Cost of Operating Equipment per Car { Cost Eastern Lines..........................
Cost Western Lines..........................

Fig. 8. Summary Statement Compiled from Two Preceding Forms (Figs. 6 and 7), Showing Cost of Each Item Per Car Per Month.

Shop Motor Section

A. C. Voltage Regulators

J. H. Wickman*

The advantages and uses of automatic voltage regulators when used with alternators are the same as when used with direct current generators. They are designed to keep the voltage of one or of several machines operating in parallel constant, so that if a recording Bristol voltmeter is connected to the line it will show nearly a true circle instead of a series of great fluctuations, as would be shown if there were no regulators connected to the system.

The General Electric type of regulators will be used as a model for the explanations and descriptions in this discussion. The desired voltage is maintained by rapidly opening and closing a shunt circuit across the exciter field rheostat. The exciter rheostat is turned so as to greatly reduce the exciter voltage and then the regulator circuit is closed by means of a small switch located on the regulator panel of the switchboard. Closing this switch short-circuits the rheostat through the contacts of the regulator and the voltage of the exciter at once begins to raise. When a predetermined point is reached the contacts open and the exciter field current must again pass through the rheostat, which is set to greatly reduce the exciter voltage. The reduction of voltage is arrested by the closing of the contacts again, which starts another cycle. These openings and closings of the regulator contact points are very rapid, so the voltage on the exciter has but an instant of time in which to fall or raise either way. It is, therefore, held practically constant at a predetermined value.

One regulator may regulate the voltage of several alternators by a special arrangement of equalizing rheostats. The total range of travel of the only moving parts is 1/32 in. from full load to no load of the alternator, so the vibrations are very rapid and allow no hunting of the machines.

Method of Operation.

The method of operation of the alternating current regulator may be best understood by referring to the diagram of connections, shown in Fig. 33, which is connected to control the voltage on one alternator. The regulator has a direct current control magnet, an alternating current control magnet and a relay. The direct current control magnet is connected to the exciter buses. This magnet has a fixed stop core at the bottom and a movable core at the top, which is attached to a pivoted lever having at the opposite end a flexible contact pulled downward by four spiral springs, although only one is shown. Opposite the direct current control magnet is the alternating current control magnet, which has a potential winding connected by means of a potential transformer to the generator or bus bars. There is an adjustable compensating winding on the alternating current magnet connected through a current transformer to the principal feeder of the system. The obect of this winding is to raise the voltage of the generator or bus bar as the load increases on the feeder, thereby compensating for line losses. The alternating current control magnet has a movable core, lever and contacts similar to those of the direct current regulators.

The relay consists of a circular shaped magnet with a differential winding and a pivoted armature controlling the contacts which open and close the shunt circuit across the exciter field rheostat. One of the differential windings of the relay is permanently connected across the exciter bus bars and has a tendency to keep the contacts open. The other winding is connected to the exciter bus bars through the floating main contacts and when the latter are closed neutralizes the effect of the first winding and allows the relay contacts to shortcircuit the exciter field rheostat. Condensers are connected across the contacts to prevent arcing and burning of the contacts.

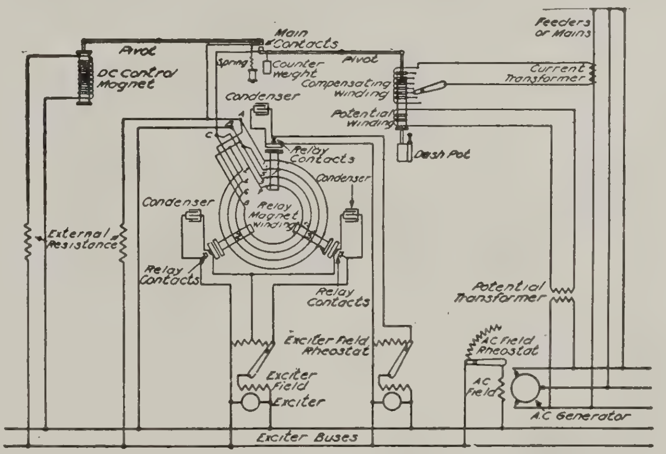


Fig. 33. Wiring Diagram of Tirrel Regulator, Showing Connections for Controlling the Voltage of One Alternating Current Generator.

Cycle of Operation.

With the main a. c. field rheostat practically cut out, the voltage of the alenator is reduced to 65 per cent. below normal by means of the exciter field rheostat. This weakens both control magnets and closes the floating main contacts, which closes the relay circuit and demagnetizes the relay magnet, thus releasing the relay armature. The springs then close the relay contacts.

The small single pole switch on the regulator board is now closed, which shortcircuits the exciter field rheostat. The exciter voltage at once begins to raise. This will strengthen the alternating current and direct current control magnets and, at the voltage for which the counterweight has been previously adjusted, the main contacts will open. The relay will then attract its armature and by opening the shunt circuit at the relay contacts will throw the rheostat resistance into the exciter field circuit, which will lower the exciter voltage. The main contacts will then close again and the operation will be repeated.

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* Foreman Electrician Shops, Illinois Central, Chicago.

Types of Regulators.

There are several forms of these Terrill regulators. A form known as type T A form F is equipped with several relays, varying in number from 2 to 12. A number is usually placed after the F to designate the number of relays—that is, a form as shown in Fig. 35 would be called form F-3 because it has three relay contacts. The principle of operation is the same whether there are three or ten relays, although certain modifications are necessary for the control of two or more generators. It will be noticed that relay No. 1 is connected across the field rheostat of one exciter, while relays 2 and 3 are connected across sections of the field rheostat of the other exciter. This is necessitated because the exciter is of a large capacity. Each case of automatic voltage regulation must be carefully studied and the best arrangements made. The regulator should have sufficient capacity to handle the total number of exciters operating in parallel, whether they are all to be in operation at one time or not.

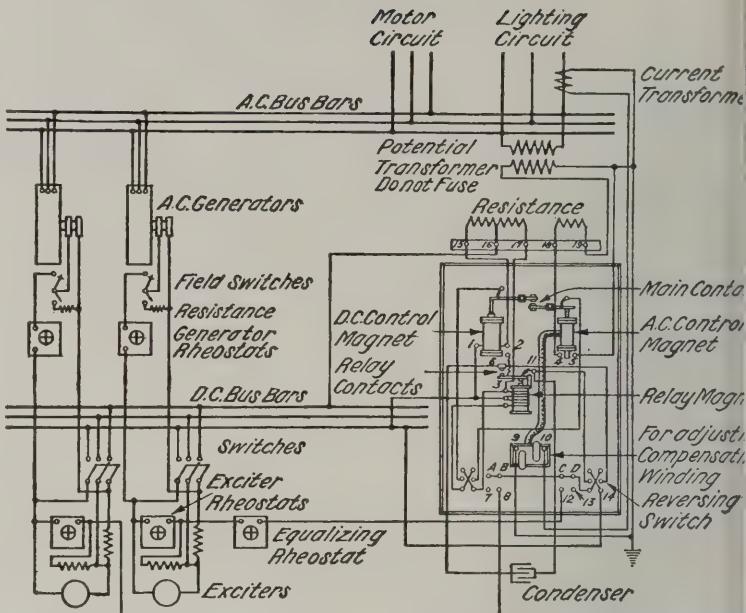


Fig. 34. Wiring Diagram of Tirrel Regulator, Showing Connections for Controlling the Voltage of Two Alternating Current Generators Operating in Parallel.

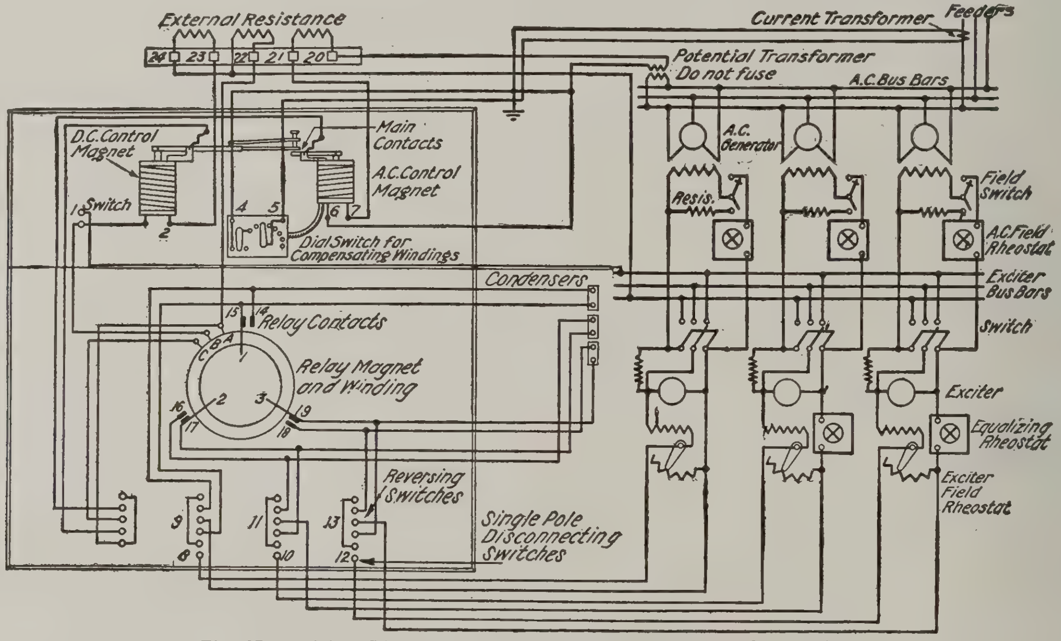


Fig. 35. Wiring Diagram of Tirrel Regulator Showing Connections for Controlling the Voltage of Three Alternating Current Generators Operating in Parallel.

Figs. 34 and 35 will give the student an idea of the wiring connections necessary when using a regulator with two or three generators operating in parallel with the exciters also running in parallel. It will be noticed that there is an equalizing rheostat used wherever there are more than one exciter used—that is, there is always one less equalizing rheostat than there are exciters.

Adjustments.

These regulators are usually regulated and adjusted before they are shipped from the factory, but should there be any occasion to readjust them a special instruction book, which is sent with each regulator, very plainly describes the details of all adjustments. This phase of the subject will not be covered in this discussion.

Troubles.

The troubles that are most liable to occur to any type of regulator will be mentioned here in part.

The troubles may be grouped under the following heads:

1—Fluctuating voltage.
2—High voltage.
3—Low voltage.
4—Error in voltage.
5—Error due to compensating winding.
6—Arcing at relay contacts.

Fluctuating voltage may be caused by: Loose adjustment screws causing improper spacing of main contacts. Friction in the lever bearings due to lack of oil. Excessive vibration around regulator foundation. Scarcity of oil in the dash pot, which should be filled to within ⅛ in. from the top and adjusted by means by the by-pass valves, so that the plunger will not work too easy. Dash pot loose on its supports. Interference between cores and windings of either direct or alternating current magnets. Loose connections. Flat spots or dirt on exciter commutator.

If the voltage on the machine runs high and the regulator ceases to work, the trouble may be caused by an improper connection, especially in the regulator rheostat shunt circuit. If connections are found to be correct see that both exciter and generator field rheostats are properly adjusted. If there is not sufficient resistance in the exciter field rheostats, the regulator cannot hold the voltage down, therefore the trouble should be remedied by the adjustment of field rheostats.

If the voltage is low and the regulator fails to build it up, the trouble may be caused by wrong connections, by improper closing of exciter switches on regulator panel, by the failure to throw the reversing switches either clear up or clear down, by an insufficient margin in the exciter field rheostat to maintain the voltage without the regulator, or by the improper setting of the alternator field rheostat.

An error in the voltage from no load to full load without the use of compensating winding must be due to the improper adjustment of the core in the alternating current magnet.

An error in the voltage when using the compensating winding, resulting in a high voltage at no load or a low voltage at full load, which requires a correction daily for different loads, shows that the levers are not adjusted properly and that the alternating current magnet voltage should be lowered by means of the counterweight.

Excessive arcing at the contacts may be caused by improper connections. Those that are supposed to shortcircuit the field rheostat are often connected so that they will shortcircuit the exciter field, which, of course, is wrong. A broken or improper connection to the condensers will also cause arcing at the contacts.

Special.

The contacts on these regulators are tipped with a special prepared metal which will withstand considerable burning and will operate for quite a long time if given the proper attention. They should, however, be kept bright and properly spaced and should be renewed when necessary.

The reversing switches should all be placed in a like position, that is, if one is up all should be up or vice versa. With reference to Fig. 35, the double-throw single-pole switches shown under the case are the reversing switches, while the next row below are the switches used to cut the regulator into service.

If an installation of Tirrell regulators is planned for any station, it is quite necessary, in order to secure an equal division of load, to first ascertain whether or not the exciters have the same regulation characteristics.

The changing of the external shunt on one generator also affects the regulation of the other machines that are operating in parallel to a certain extent on account of the connection through the equalizer.

Another important point is that the air gap varies on different machines and it is often necessary that the air gaps be made alike, or nearly so, before the machines can be paralleled. This is easily done by shimming up the pole pieces on the machine with the greater air gap.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 46

Consolidated Type "L" Equipment

Although this equipment was discussed to considerable length in our Lessons, No. 20 and 31, certain modifications, recently made, warrant further comments. In this lesson we will also endeavor to cover certain points in the construction of the equipment in more detail than was done before. The operating and maintenance features will be fully covered in a future lesson.

The Generator.

The generator is a four pole shunt wound machine without compound fields, but with two interpoles as shown in Fig. 235, these latter being labeled "AA."

The function of the interpoles is to eliminate sparking at the brushes under all conditions of load and speed by neutralizing the cross magnetism of the armature. As the magnetism due to the armature current increases with the load, it follows that the neutralizing effect of the interpoles must increase at the same rate. The interpoles are, therefor, connected in series with the armature circuit. This connection is made on the armature side of the pole changing switch to insure a reversal of interpole polarity with each reversal of armature polarity. The magnetism generated by the interpoles, therefore, at all times neutralizes the cross magnetism generated by the current flowing through the armature coils.

The Interpoles.

It will be noted that there are but two interpoles, whereas there are four main field windings. These two interpoles are twice normal size, however, as each does the work of two ordinary interpoles. Electrical men who have become accustomed to seeing interpoles between all field coils may wonder how two interpoles are made to do the work of four as usually employed. Accordingly, the diagrams, Figs. 236, 237 and 238, showing the flow of magnetism through the generator frame and pole pieces, will be of interest. For the sake of clearness we have not shown the magnetic lines of the main generator poles. The heavy curved arrows shown in the center of the commutator ring represent the cross magnetism or armature reaction generated by the main current flowing through the coils of the armature. The fine dotted lines represent the flow of magnetism generated by the two interpoles.

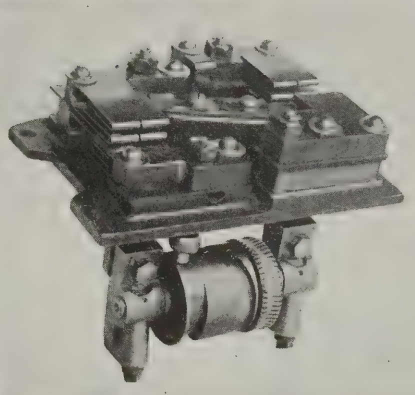


Figure 230. First step in throwing the pole changer upon reversal of car motion. Note the cam follower is just entering the groove in the cam.

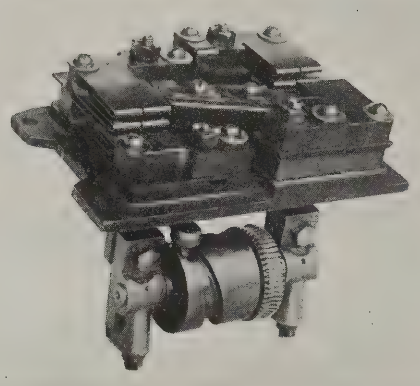


Figure 231. Second step. Note that the cam follower is being forced over to the right as the came revolves. The switch blades still engage the front contacts at the right.

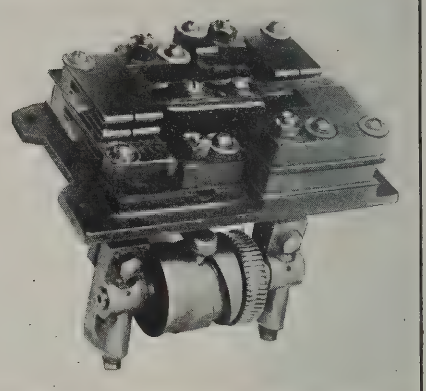


Figure 232. Third step. Cam follower thrown half way over and switch blade midway between the clips.

It will be noted that when the armature is revolving in a right-hand direction, as shown in Figure 246, both of these interpoles (shown solid) are north poles, whereas when the armature is revolving in a left-hand direction, as shown in Figure 237, both of the interpoles have become south poles, due to the reversal of current flow through the armature and interpole coils.

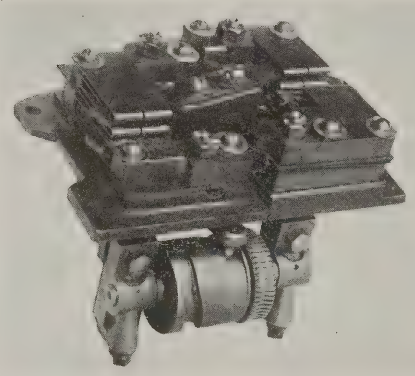


Figure 233. Fourth step in changing polarity. Note that cam follower is thrown to the extreme right and that knife blade now makes contact with the rear switch clip.

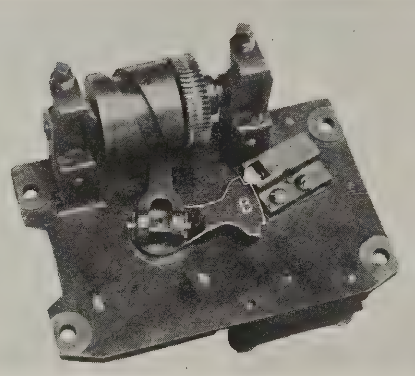


Figure 234. Bottom view of the pole changer showing the cam "B" with bevel pointed spring follower. This completes the throw of the switch and relieves the pole changing cam from wear when not actually reversing connections.

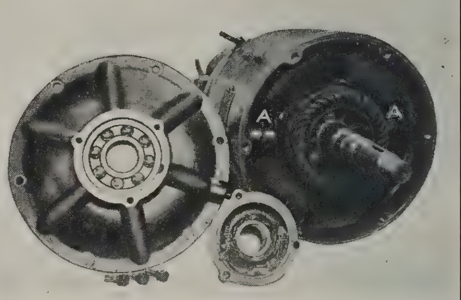


Figure 235. Generator with the pulley end housing and bearing plates removed. The two interpoles are shown at "A-A." These interpoles are all of the same polarity, both north poles when running in one direction and both south poles when running in the reverse direction. They induce interpoles of opposite polarity at the top and bottom positions, as explained.

The result of having two poles of the same polarity at opposite sides of the armature is to induce two other poles of opposite polarity midway between these two; in other words, a south pole is induced at the top and another at the bottom point on the armature surface, as shown in Fig. 236. These imaginary poles are shown dotted.

Of course, there is no iron in this position, so the magnetism will not follow a path midway between the two main pole pieces, but will rather crowd into either one or the other of the main pole pieces, depending upon which way the armature is revolving. It will be noted that the main field coils are not equally spaced, being closer together at the top and bottom than at the sides.

When operating as shown in Fig. 236, this interpole magnetism creates a north pole at each side and a south pole at the top and bottom, as shown. When the direction of rotation is reversed, however, as shown in Fig. 237, the polarity of the brushes and the direction of the armature reaction magnetism will both be reversed, but at the same time magnetism of the interpoles is also reversed, due to the reversal of current flow through the series winding on change in polarity, and here again the interpole magnetism neutralizes the cross magnetism of the armature reaction.

As explained before, instead of actually inducing another interpole at the top and bottom of the machine, the interpole magnetism crowds into leading pole tips, the magnetism at which point has been weakened by the effect of the armature reaction, as shown in Fig. 238. When the direction of motion is reversed, the interpole magnetism then shifts over so as to feed through the right-hand edge of the top north pole so that the tip of the pole is then the leading tip and its magnetism is weakened. A corresponding shifting of the interpole magnetism takes place at the bottom, the left-hand edge of the lower north pole here being strengthened. The diagram, Fig. 239, shows the distribution of magnetism and the exact effect of using the interpoles. The dotted lines show the magnetism with no interpoles and it will be noted that here the brushes commutate under a fairly heavy field, which would cause sparking, whereas, with the interpoles the magnetism at the commutating position is very low, hence, little sparking.

Of course, the magnetism of the main generator field varies inversely with the train speed, being weakest at the highest train speed. The magnetism of the interpole winding, however, for a constant generator output is a constant value and accordingly it might seem that the interpole at certain very high speeds might be able to overcome the main winding, or at least materially affect it. This, however, is not the case, for the function of the interpole is simply to neutralize the ampere turns of armature reaction, generated by the current flowing through the armature. Since the number of armature conductors remain constant and the armature current also constant, the ampere turns of armature reactions will be constant. Therefore, with a constant magnetic strength in the interpole field, this will at all times exactly neutralize the armature reaction, whatever the operating speed of the generator may be, and the main generator field will be unaffected. Where no interpoles are employed the main generator fields, which are weakened at very high speeds, may be seriously affected by the armature reaction.

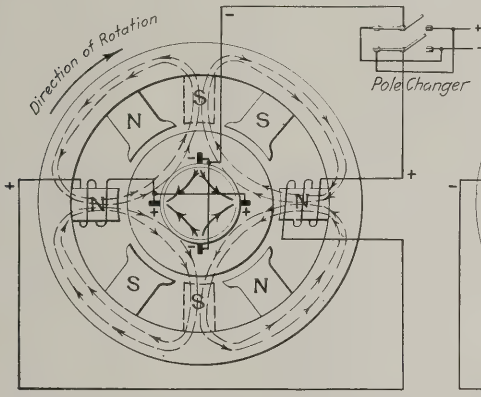


Figure 236. Sectional diagram through generator showing how two interpoles take the place of four, as usually employed. Two other interpoles are induced at the top and bottom of the generator, as shown dotted. Heavy arrows at the center indicate the magnetism of armature reaction. Note that the magnetism of the interpoles opposes this.

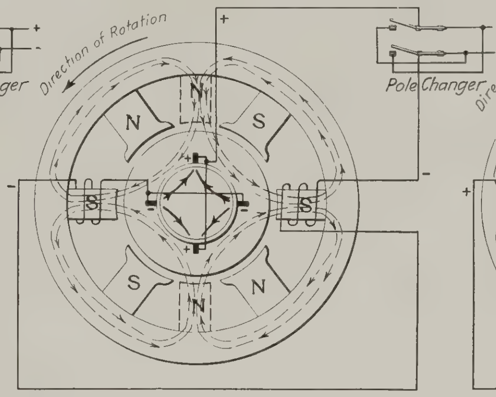


Figure 237. Same thing as 236, except rotating in the reverse direction. Note that brush polarity is reversed and that the polarity of the interpole is also reversed on account of current flowing through the armature and series coils of the interpole in opposite direction to Fig. 236.

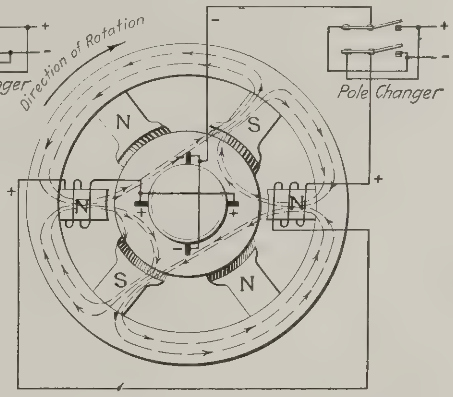


Figure 238. The two previous diagrams show how two additional interpoles are induced at top and bottom of the generator. There being no iron between the main fields; top and bottom, however, the magnetism instead of flowing between the two fields, as shown, will actually flow through one edge of one of the main fields, depending upon which direction machine is rotating. Note how the interpole magnetism strengthens the weakened parts of the main field.

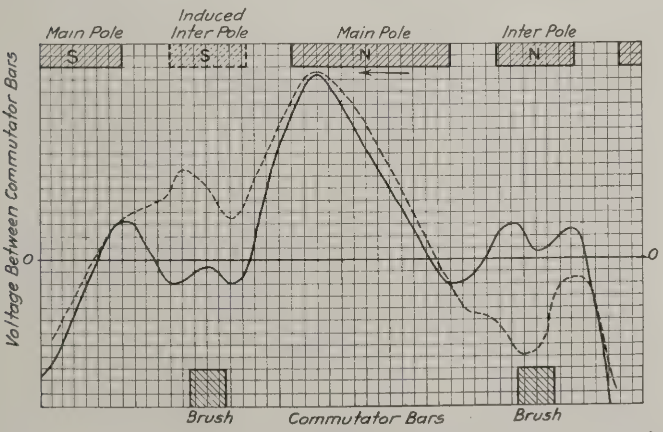


Figure 239. Showing the magnetic distribution across the pole faces. Dotted line indicates magnetism without interpole and the solid line indicates magnetism with the interpoles operating. Note how the interpoles reduce the magnetism to practically zero at the point of commutation.

The Pole Changer.

The operation of the pole changer is clearly shown in the moving picture diagram, Figs. 230 to 234, inclusive, which show the various steps in throwing over the pole changer. The worm gear of the pole changer is driven by a worm cut on the end of the armature shaft. This worm gear is thus driven at a comparatively slow speed, the ratio of operation being 1 to 20. As will be noted from the illustration, the operating cam is mounted directly on the worm gear. The groove in the cam is cut on a spiral and when the direction of motion is first reversed, shown in Fig. 230, the cam follower enters the groove and is then forced over to the right, as shown in Figs. 231, 232 and 233. When it reaches the position shown in 233, it is practically at the end of its travel, but here an ingenious device is provided in order to relieve the pressure of the follower on the cam. The under side of the pole changer, Fig. 234, shows how this is accomplished. A cam B is mounted on the knife blade element of the switch and turns with it, and when the switch nears the end of its motion a small spring latch forces the cam over into position and completes the throw of the switch, thereby relieving all pressure of the cam on its follower and allowing the follower to float without any further wear on either cam or follower during all successive revolutions of the worm gear.

The pole changer switch, as shown in Figs. 230 and 233, is really a double throw, double pole switch, the clip at the left-hand side being the center of the double throw switch. The switch clips are all made with a reverse bend so as to insure uniform pressure over the entire surface of the knife blade.

Bearings.

The generator is furnished either with the straight line sleeve bearing or with any of the standard makes of ball bearings or roller bearings. The straight line sleeve bearing furnished with this equipment, however, is unusually large. The method of removing ball bearings or sleeve bearings will be taken up more fully in a later lesson.

The Railroad Electricians' Club

Excessive Growth of Battery Plates

Planté type battery plates frequently grow excessively in car-lighting service and it is therefore profitable to consider some of the things which cause it. Excessive growth of the plates almost always occurs in the positive group. This is because an abnormal amount of active material is formed, and as this is lead sulphate and lead peroxide in a more or less spongy state, it occupies considerably more space than did the original lead from which sulphate and peroxide was formed. This fills the spaces between the ribs of the plate with active material and as still more active material is formed, due to further oxidization of the lead, the plate expands to accommodate the new material formed.

In normal operation of the battery there is always a gradual formation of the reserve lead in the positive plate. This takes place at a rate just about equal to the shedding of active material from the outer surfaces of the plate, so that the total capacity of the battery is kept about constant and the plates are not stretched by an oversupply of active material.

There are certain chemicals which are frequently found in storage battery electrolyte as impurities which cause excessive formation of active material in the positive plate, and it may be said that these impurities are usually the cause of abnormal growth in plates; low rate charging, however, will cause this even though there be no apparent impurities in the electrolyte. One of the most common impurities of this kind is a certain amount of forming agent which was used in the original manufacture of the plates and which was not entirely removed in the process of manufacture.

There are various types of forming agents commonly employed in battery manufacture, forming either the nitrate, acetate, chlorate or perchlorate of lead, all of which are soluble forms of lead and which form the first step in the rapid formation of the lead plate during manufacture. Some of these forming agents are more stable than others, but nitric and acetic acid are decomposed by battery action and will be ultimately almost eliminated as an impurity in the battery. Perchloric remains and traces of others. Trouble occurs where these traces of forming agents exist in such quantity that they form up a large percentage of the reserve lead in the plate before they are finally decomposed by the current action.

It is a peculiar fact that nearly every kind of wood contains certain substances which are coming in contact with sulphuric acid form acids, such as acetic acid, formic acid and tannic acid, these collectively being known as "wood acid," and all of these may act as a forming agent if found as an impurity in the battery electrolyte. Some woods, such as maple, pine, oak, etc., contain a large amount of wood acid, whereas swamp woods, such as cypress and cedar, have very little.

Wooden battery separators are usually treated chemically to remove dangerous amounts of the wood acid before being used as separators in the battery.

There have been many cases, however, where ordinary strips of bass wood have been used as separators between the plates, or where wooden blocks have been used as bottom rests in the cells, and in many cases such wood has been the cause of serious plate formation in the batteries.

The wood acid is soon washed out of the wood fibre by the sulphuric acid of the electrolyte and once in the electrolyte, the wood acid immediately begins action on the reserve lead of the plate, forming active material. The chemical action which takes place is more or less simple. The acetic acid of the forming agent attacks the metallic lead of the ribs, deep down under the active material of the plate, forming lead acetate, which is soluble. This, soluble salt in trying to dissolve in the electrolyte at the point of formation, however, immediately comes in contact with the sulphuric acid of the electrolyte with which all the active material is soaked and accordingly at once forms a very thin layer of the insoluble white lead sulphate over the metallic surface of the ribs. The action of the electric current on charge soon reduces this lead sulphate to peroxide, which is the normal active material of the positive plate.

The wood acids producing the forming action on the positive plates, due to the impurities mentioned, is believed by some to also take place at the negative plate, but to a less degree. Here, strange to say, a small amount of some of the trouble-making impurities, mentioned above, actually appear to be beneficial for the negative plates. The explanation of this point is simple. Others, however contend that the improvement is due simply to the lower resistance of the wooden separator.

In normal battery operation the fine grains of the sponge lead, making up the active material of the negative plate, tend gradually to form larger and larger grains. The result of this is that much of the sponge lead is rendered inactive because of the fact that it is in the center of the larger grains. The active surface of the sponge lead is correspondingly decreased and the capacity of the negative plate is lowered. This process is known as "hardening of the negatives" and is a frequent source of loss in battery capacity.

The forming action of some of the wood acid impurities, however, tends to break up any of this formation by attacking the grains of metallic lead, forming first the soluble lead salts and immediately afterward lead sulphate, which on the next charge is broken up into sponge lead and sulphuric acid which goes back into the electrolyte.

It is thus seen how these impurities, which ordinarily are very injurious, may be somewhat beneficial if they exist only in very dilute form. It must be remembered, however, that untreated wood in a battery is usually injurious and its use should be avoided when possible.

Personal Mention

Harry D. Rohman

Car lighting engineers of this country and abroad will be interested to learn of the entrance of the Franklin Railway Supply Company, New York, into the American car lighting field. The Franklin Company are now manufacturing and placing upon the American market the "Stone System" which has been so extensively employed in all parts of the world, there being approximately 70,000 railway cars lighted by this system now in service. The many friends of Mr. H. D. Rohman across the water and his numerous more recent friends in this country will be interested to learn of his recent appointment as chief electrical engineer of the Franklin Railway Supply Company, with headquarters at the New York office of that company.

Mr. Rohman was born in Switzerland in 1883 and received a technical training as electrical engineer in the University of Zurich. After graduation he entered the works of the Oerlikon Electrical Construction Co., where he was afforded an opportunity of combining the theory of electrical engineering with actual practice among the men on the job. While with this company he also had considerable experience with high voltage a.c. and d.c. work.

He later entered the service of J. Stone & Company, London, and gradually worked up through the various departments of the company, gaining experience in all branches of the business, until in 1910 he was appointed chief of the testing and experimental departments. In April, 1914, he was appointed chief assistant electrical engineer and held that position until October 1, 1915, when he entered the service of the Franklin Railway Supply Company.

Mr. Rohman has had a very wide experience with car lighting equipments operating under all sorts of conditions in various parts of the world. He spent over a year in making a thorough study of conditions and overcoming the difficulties of operating car lighting systems over a railroad running for 2,000 miles through the heart of Africa, where the hot desert sands, heavily laden with iron dust, combined with the ignorance and unreliability of negro native maintainers, seemed for a time to be almost unsurmountable difficulties.

In contrast with this, Mr. Rohman "kept the cars lighted" on the railways of the Balkan states operating in the winter time through the most severe Siberian weather of the Russian steppes. Mr. Rohman speaks several languages and undoubtedly his wide experience with car lighting conditions, although very different from those encountered in this country, will make it possible for him to offer some valuable suggestions to American car lighting engineers.

Thomas L. Mount

Thomas L. Mount, who was elected president of the Railway Electrical Supply Manufacturers' Association at the recent A. R. E. E. convention at Chicago, has been a live wire in the car lighting game for nearly 15 years.

Tom, as he is best known among his car lighting friends, was born in 1880 and received his early education at the Trinity school, New York City. This was supplemented by a course in electrical engineering at Columbia University.

He entered the employ of the Consolidated Railway Electric Lighting & Equipment Company as a draftsman the same year and was later employed in the factory as machinist, inspector and electrician in charge of maintenance of car lighting equipments on various railroads. He later entered the sales department and also served as assistant to Mr. P. Kennedy, chief engineer. In 1913 he became a member of the board of directors and in 1915 was elected third vice-president.

With the Franklin Railway Supply Company.

Frank R. Peters, formerly with J. Stone & Co., London, has joined the electrical staff of the Franklin Railway Supply Company.

C. B. Little, one of the electricians of the Baltimore & Ohio Railroad, has resigned to accept service with the Franklin Railway Supply Company.

Henry C. Kloos, of The Pullman Company's electrical staff, has accepted a position with the Franklin Railway Supply Company.

With the Westinghouse Electric & Mfg. Company.

The Westinghouse Electric & Mfg. Company announces a number of changes in the supply department which have recently been put into effect.

Messrs. S. A. Chase, formerly special representative, T. J. Pace, formerly in charge of illuminating and rectifier divisions, and Carl G. Schluederberg, formerly head of switchboard sales, have been appointed assistants to manager, Mr. J. J. Gibson.

Mr. C. E. Stephens, engineer of lighting, has been appointed manager of the illuminating section to succeed Mr. Pace. Mr. C. Streamer, formerly head of the order division, succeeds Mr. Schluederberg as manager of the switchboard section, and Mr. A. P. Joseph is appointed head of the order section to succeed Mr. Streamer.

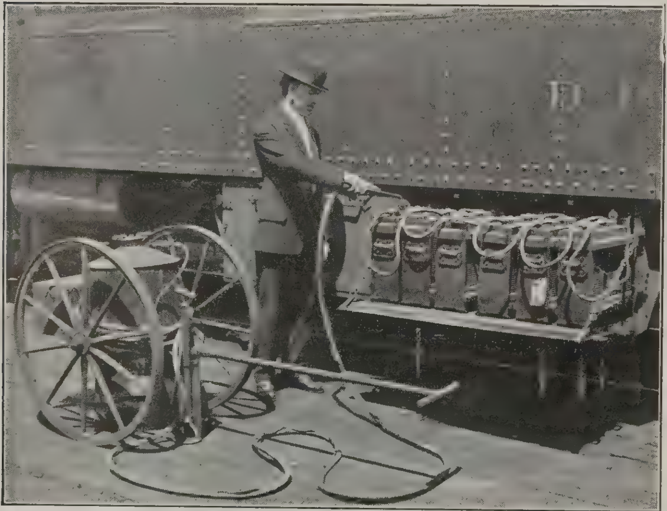
Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Air Pressure Battery Flushing Cart

The illustration shows a two-wheeled cart with wide tires, which is very convenient for use about yards where the paving is poor to get distilled water into the batteries in the cars.

Our water still is so arranged that the distilled water flows into a barrel which is fitted with a brass valve at the bottom. Both the still and the barrel are mounted high enough to allow the cart to be backed under the valve and easily and quickly filled.



The air pressure flushing cart in use. Jess Younger, electric foreman, Chicago coach yards flushing an Edison battery. Note that the cells are not removed from the battery box door.

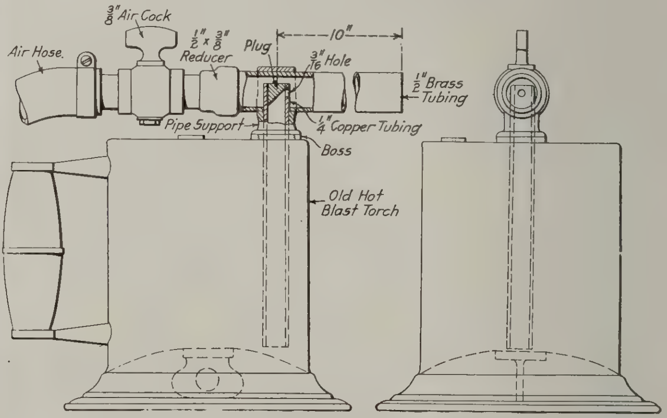
A battery on a car is flushed within fifteen minutes with this cart, as chains with a hook are used to keep the battery box door in a horizontal position. As each battery is pulled out on the door, all vent caps in the battery cells are opened, and as each battery is flushed, the vent cap is closed.

Air pressure, maintained by a small hand pump, forces the water into the battery tanks.

E. W. Jansen, Elec. Engr., I. C. Ry. Co., Chicago.

Paint Sprayer for Painting Batteries

The sketch shows a paint sprayer designed by the writer and used successfully in the Sunnyside yard of the Pennsylvania Railroad for painting Edison batteries. It will be noted that the sprayer is made from an old blow torch by the addition of an atomizer, an air cock and a pipe for attaching an air hose.



Paint Sprayer for Painting Batteries.

We found by experience that it required about 30 hours to paint the batteries with an ordinary paint brush. When using the sprayer we can paint the cells and trays thoroughly in about six hours, or one-sixth the time formerly required.

Another advantage of the sprayer is the saving in paint effected by its use, which is one quart for every set of batteries painted.

W. C. Kershaw,
Foreman, Electric Car Lighting, Sunnyside Shops,
Pennsylvania Railroad.

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ELECTRICAL ENGINEER

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Car Lighting Development During 1915

The total number of passenger cars built during 1915 almost reached the low-water mark of 1908, there having been only 1,949 passenger cars built during the past year. The large number of orders placed during the latter part of the year, however, brought the total number of cars ordered during 1915, namely 3,092, up to a fair average. Of this number of cars ordered, 2,767 cars, or practically 90 per cent, were to be electrically lighted.

Although the year has been more or less quiet in the matter of original development and improvement on the part of the railroad companies, there has been some notable exceptions. The new system of deck lighting from semi-concealed units in the quarter deck—as used in the new steel dining cars and coaches recently built for the Northern Pacific—is a novel development of the year in car lighting, although this principle of lighting has been employed rather extensively heretofore in other classes of service.

There have been a number of interesting developments in the systems of car lighting employed. The head and axle generator system, in which a 17½ kilowatt unit is mounted on top of the forward truck of the baggage car and, projecting into the baggage car, furnishes light for the entire train, has been successfully applied on the Northern Pacific Railway. Two such units were purchased during this year and are in operation between Minneapolis and Duluth. The regulating system employed is simply a Gould simplex regulator on a large scale.

The body-hung suspension seems to be coming into vogue, and during the past year the Safety Car Heating and Lighting Company has placed on the market a completely redesigned generator, with special provisions for maintaining constant belt tension, to meet the special conditions imposed by this new generator position.

Another interesting development in this connection is the recent active exploitation in the United States of the Stone system of car lighting, so extensively employed abroad, by the Franklin Railway Supply Company. Special features of this equipment will be described in an early issue of the *Railway Electrical Engineer*.

Motor Efficiency

In drawing up specifications or requisitions for motors to be used in railroad service, we are sometimes prone to give too much weight to the operating efficiency of the motors or generators being purchased.

The real function of a motor is not to consume a certain amount of energy from the transmission line and deliver it at a certain high efficiency in mechanical power to the machine tool, but rather to give service in making the wheels go when most needed.

It is unquestionably true that a motor too large for the service will operate at poor efficiency. It is likewise true, however, that in railway service there come times of extreme rush, in which it becomes necessary to push locomotives or cars through the repair shops with the greatest possible speed. At such times any delay in work on locomotives or cars mounts rapidly into large sums in money lost, due to not having power or rolling stock available for hauling freight.

At such times shop motors must operate for days, or even weeks, at two or three times their normal maximum load, and here a motor properly selected by a purely scientific individual to operate at a proper efficiency for its normal maximum load may fall down completely and fail to perform the service required of it in times of stress.

Ability to stand up under overload is a far truer measure of the real worth of a motor than a few points up or down in the scale of motor efficiency, and certainly more than a few dollars more or less in the price of the motor.

The Value of White Walls and Ceilings

White ceilings and white walls increase the illumination efficiency of nearly any lighting system from 20 to 50 per cent. Although this is particularly true where artificial illumination is employed, it is also true of daylight illumination. A deplorable number of lighting installations have been made without any consideration as to the efficiency or effectiveness of the system, and after being once installed are completely forgotten unless a lamp burns out, when it is simply replaced. Men of modern efficiency ideas are appreciating more than ever before, not only the importance of keeping the illuminating glassware and reflectors clean, but of the value of white walls and ceilings.

Railroad service is unusually severe on any lighting system because of the smoke and soot conditions encountered and it is not at all unusual to find a lighting system which has depreciated in two or three months to but half of the original lighting efficiency, where reflectors and lamps are not cleaned.

White walls and ceilings have a double value in increasing the lighting effect, for the light is reflected again from the white surfaces and adds to the total floor illumination instead of being absorbed as in the case of black walls, and at the same time it is much easier to see dark objects, as iron materials, machine tools, etc., against a white background than against a dark background.

The actual increase in foot candles illumination provided is by no means the only advantage, for the general air of cheerfulness always accompanying plenty of light has a big dollars-and-cents value in increased efficiency of the workmen in railroad shops, freight houses, terminals, etc.

The principle of white ceilings can also be very advantageously employed in railroad cars and in railroad stations. The design of modern cars, particularly those of the turtle back type, is nicely adapted to employing light ceilings, but even with the monitor type roof a light yellow ceiling panel and quarter decks are not only effective from the illumination standpoint, but are artistically beautiful as well. It is a source of pleasure to the illuminating engineer to witness the passing of the heavy dark wood car interior finish, as is taking place so generally in modern steel car construction.

Car Lighting Accounts

It frequently becomes desirable to compare the cost of electric car lighting on one road with similar costs experienced on other roads. Any railroad official, however, who has attempted to make such a comparison, appreciates the difficulties of such a comparison due to the non-uniformity of keeping these accounts. Practically every railroad has a different method of accounting and, of course, the general accounting system which is employed by that road will largely determine the manner in which the car lighting costs are kept. This no doubt explains the chaotic condition which now exists in car lighting records, where there should be a uniformity of methods on the various railroads.

The article by Mr. E. S. Macnab on Electric Lighting of Railway Cars in the December, 1915, issue, contains important information on this subject, including numerous record forms in use on the Canadian Pacific Railway. We expect to publish similar accounting forms in use by other railroads, in the course of the next few months, and will eventually make a thorough study of the situation.

It will be remembered that a special committee of the A. R. E. E. reported on this subject at the 1912 convention of the association, and at that time presented standard forms which were recommended for keeping car lighting costs and which were accepted by the association. It is certainly to be regretted that more extensive use has not been made of these standard forms by car lighting men in keeping their own records and in exchanging costs with other railroads.

Cutting in Speed for Axle Generators

The speed at which an axle generator develops normal voltage and begins to carry the light and battery load is of minor importance on most runs, but in other classes of service, such as on branch lines and on heavy mountain grade divisions, where the train operates at a comparatively slow speed and with frequent stops, the speed at which the generator cuts in becomes a factor of vital importance in the operation of the equipment.

There are a vast number of branch lines and local runs in which as high as twenty-five stops in a fifty-mile run must be made, and where a maximum speed of twenty-five miles per hour is rarely obtained. In considering the problem it is also necessary to consider the rate of acceleration of the train; ordinarily, however, the change in speed from zero to ten miles per hour is made in about one-quarter of the time required for the change in speed from ten to twenty miles per hour, and very frequently the train operates for a considerable period of time at a speed of from twelve to fifteen miles per hour. Under these conditions the time of generator operation with a machine designed to cut in at ten miles per hour may easily be twice as great as that of a machine set to cut in at eighteen miles per hour.

A generator designed to operate between a speed of ten miles per hour and seventy miles per hour must, of course, have its effective field strength reduced at highest speed to but one-seventh of the field strength at cutting-in speed. It is a well-known principle that a slow speed motor is much larger than a high speed motor of the same horsepower; for the same reason an axle generator designed for a low cutting-in speed must be larger and have more powerful fields than one of the same capacity designed for a higher cutting-in speed.

Another angle of the problem, rarely considered, is that the generator voltage does not always follow the rise in train speed. A comparatively low resistance in the generator field circuit will greatly reduce the speed at which the generator voltage builds up. By eliminating or short-circuiting this resistance in the field circuit at the period of building up the voltage, it is quite possible that the time of generator operation may be increased without actually changing the design or cutting-in speed of the generator.

Electrification Progress in 1915

By George Gibbs*

Consulting Engineer, New York

During a year of great disturbance in all business conditions little has been done in the way of initiating new railway projects, but the period has witnessed the completion of two very important electric traction installations and the partial completion of a third on steam railways. All three represent departures in important details from previous installations and practical results will be watched with interest.

On the Norfolk & Western a freight haulage installation was undertaken to relieve congestion by an increase in train speed and also to produce operating savings on the heavy grade division over the Allegheny mountains; it is conducted under unprecedented conditions as to density of traffic and train weight.

The suburban passenger train electrification of the Pennsylvania at Philadelphia is an application under complicated terminal conditions of an electric system which is designed to be adapted for future extension over long distance main lines and to then handle all classes of service.

The Chicago, Milwaukee & St. Paul electrification in Montana and Idaho applies electric traction to heavy train units, both freight and passenger, on a line having heavy traffic and over the longest distance yet attempted; it is being carried out by an electric system quite different in detail from that employed on the two railways first mentioned.

These installations, added to others already in operation, furnish examples, representing practically all conditions and kinds of railway service. Their purposes are various. Electric traction has been employed to make underground terminals in large cities practicable; to facilitate safe operation in long tunnels; to increase the capacity of lines or of passenger terminals; and to increase the operating capacity on heavy grades. In certain of these cases increased economy of operation is an important and perhaps a controlling consideration. The reasons, therefore, have been either compelling ones from an operating standpoint, or those connected with expected economies.

The success of this form of traction may be viewed from different standpoints, accordingly as the inquirer sets the problem for himself. Technically, it has been amply demonstrated that electricity can propel trains of any weight at any speed, not limited by other considerations, and that the apparatus required will function reliably; in fact, notwithstanding the complicated mechanism involved and the circumstance that an electric system is tied together from the power house to the trains, thus requiring that all links must operate to secure service, operation has been found remarkably reliable, and, in this respect, an advance on steam operation which it superseded.

Increased capacity has been obtained from electric operation, both as the result of its ability to concentrate almost unlimited power at the train, and thus increase speed and hauling capacity under adverse conditions, and because in certain kinds of service, such as suburban passenger, multiple unit motor car operation is substituted for locomotive operation, thus reducing shifting and idle movements in congested terminals.

As regards the aspect of economy, this is not yet as clearly defined as might be expected, considering the number and variety of installations already made. Some of these installations are as yet too new to furnish comparison, but a factor of more importance is that in nearly every case new conditions have been introduced with the new form of traction, and thus the same things cannot be compared. Another fact is that the actual cost of an existing steam service is frequently as much in doubt as the probable cost of electric operation which is to replace it. This peculiar condition exists because railway accounts are not thoroughly segregated for the cost of each part of the equipment or for each operating division as a whole, much less for a particular service on part of a division, as is often required.

Generally speaking, the most attractive fields for electric operation from the standpoint of increased direct net money return on the investment are: (1) where traffic is dense over an entire division and where the train loads, or speeds, or both, may be increased by electric operation, thus utilizing motive power more effectively than with steam; (2) for traffic having a high load factor, i. e., a fair degree of uniformity throughout the day, so that trains may be operated with reduced power and labor costs. Long lines with thin traffic and terminal station operations do not generally furnish an attractive field for electric traction from the standpoint of operating savings, although in some cases such installations may prove profitable where the cost of energy can be largely reduced by obtaining it from cheaper sources.

The indirect benefits of electric operation are, however, often controlling in any installation, and among these may be mentioned smoke elimination in tunnels and underground terminals, increased comfort, speed and attractiveness in passenger service, and the increased line capacity referred to above.

It is, therefore, to be expected that electric traction will continue to develop as regards methods of application, and will be used in the many cases where it is well suited to or is required by surrounding conditions. Electric traction apparently cannot supersede steam traction for all, or for even a very large part of the railway mileage of the country, unless some radically new type of apparatus should be developed, a contingency which, unfortunately, does not seem at present to be pending.

A word may be said regarding the technical developments which have occurred or have become realized during the past year. Electric traction has for several years been tending towards extension to long distance, or, rather, to entire divisional operation; this is in many cases almost essential for proper railway operation, as intradivisional transfer of power or train is costly and inconvenient. Long distance and heavy train-unit traction has made a change desirable from the expensive method of distribution of low tension direct current power to the trains by third rail conductors, which requires large capacity of feeders and sub-station machinery. The three installations completed this year all illustrate the present tendency to use an overhead trolley wire of small size, but large power capacity, by reason of the high potential of the current carried. The Norfolk & Western and Pennsylvania installations use an alternating current system throughout and distribute current at very high potential; the St. Paul's installation uses direct current in the trolley wire at a potention which is high compared with that used in a third rail, but low compared with the practice in alternating current systems. Standardization, therefore, of electric systems as a whole cannot be said to be complete, but progress has been made toward the use of overhead conductors as a standard, and in the case of the alternating current systems, toward uniform characteristics of the current used in the working conductors.

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We may, therefore, as regards further developments, properly await experience with the two overhead systems now on trial. The relative first cost of these two systems does not appear, from present information, to differ greatly and the further development of both will doubtless proceed for some time. It may well be that both will find a place in heavy railway work unless one of them is shown to be greatly superior as regards simplicity, reliability and cost of operation. It is especially important, therefore, that each new installation undertaken should be based upon a competent examination, not only of the railway operating features, but of the complex technical developments now taking place, in order to clarify the problem for the future.

Formal Opening of the St. Paul Electrification

The first engine division of the electrified section of the St. Paul, consisting of 112 miles and extending from Three Forks to Deer Lodge, was completed by the end of November, 1915. On November 30 the trolley system was energized, and on December 1 a train consisting of an electric locomotive and a few business cars was run over the line. During the following week various test runs were made, and finally on December 8 an exhibition run was made for the president of the railway, directors and others interested. This run consisted in hauling over the division a 3,000-ton train, handled by a single electric locomotive on grades under one per cent, and by two electric locomotives on grades over one per cent. The grade through Janney, where the president's party was assembled, is 1.66 per cent.

The electric train was hauled over the grade quietly and easily, and passed the party running at the rate of about 15 to 16 miles per hour. Following behind this train came another of 2,000 tons hauled by two of the company's type "L" steam locomotives, with the help of one Mallet pusher. In spite of the fact that this train was only two-thirds as heavy as the first, the three steam locomotives had difficulty in going past the party at the rate of about 10 miles per hour.

It has developed that the 282-ton electric locomotive used by the St. Paul can handle considerably more tonnage than the builders guaranteed, and also that its system of regenerative braking has proven exceptionally successful. In this connection a preliminary test made over the tracks of the Butte, Anaconda & Pacific may be of interest. On November 13, 1915, one of the first electric locomotives to be shipped hauled a 4,941-ton train (including the weight of the locomotive) from Rocker to the Anaconda yards without the use of air-brakes, except to stop at Durant and Anaconda. The regenerative control was used to hold the train on the one per cent down grade, and during this time as much as 880 amperes or approximately 2,100 k. w. (at 2,400 volts) were returned to the trolley. To determine definitely just what could be done with this method of braking the train was allowed to reach a speed of 25 miles per hour on the one per cent down grade. When the electric brakes were cut in the speed was reduced to 7 miles per hour gradually and smoothly. The reduction in speed was accomplished without any perceptible jar to the train. With all the braking effort concentrated at the locomotive, the slack between cars is bunched, therefore eliminating all danger of a "break-in-two" from that cause. The tests of this type of electric braking on the Butte, Anaconda & Pacific showed that a train going down grade can return 21 per cent of the electrical energy required to move the same train up the same grade at the same speed. In cases where an electric locomotive is used as a pusher a run-around track is provided at the top of the grade to enable the "pusher" to go to the head-end of the train, so that it can assist with the electric braking on the down grades without taking the slack out of the train.

The operation of electric locomotives over the 112-mile division between Three Forks and Deer Lodge marks the completion of the first part of the entire electrification project covering 440 miles of main line and about 200 miles of side tracks, making a total of 640 miles. Details of this electrification were given in the December, 1914, and January, 1915, issues of the *Railway Electrical Engineer.*

All tests of the new electrification have been particularly successful, and on December 9 the first passenger train, the St. Paul's crack transcontinental "Olympian" was taken from Butte to Piedmont by an electric locomotive.

The Effect of the Recent Blizzard on the New Haven's Electrified Zone

The severe wind, snow and sleet storm which swept the upper Atlantic Coast states on December 13 concentrated its efforts and reached its greatest proportions over that section of New York and Connecticut traversed by the electrified lines of the New Haven. Further inland more snow fell, but along the coast the wind reached its maximum velocity, and there the snow was a freezing sleet.

The wind at one time reached a velocity of 75 miles per hour, and the sleet froze on the wires to an average thickness of 1⅜ in., the total diameter over the ice in many instances being 3¼ in. This storm was very similar to the great storm of March 2, 1909, which almost completely isolated the city of Washington on the eve of Mr. Taft's inauguration.

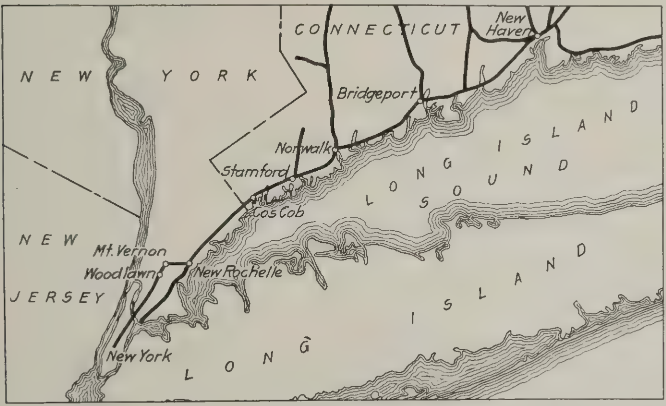


Fig. 1. Map Showing the Storm-Swept Section of the New Haven.

The natural and immediate result of such a severe storm was to demoralize all railroad traffic in the area affected. The New Haven suffered the greatest damage because, as above stated, its lines run along the coast, where the storm conditions were at their worst.

Early in the afternoon on Monday, December 13, ice began to form on the telegraph and telephone wires carried on wooden poles along the edge of the right of way, also on the telephone, signal, control, feeder, transmission and catenary trolley wires carried on the steel catenary supporting structures. The ice seemed to form faster on the smaller signal, communication and control wires.

Finally the ice became so heavy that the wires started to break here and there all the way between Woodlawn and New Haven. By six o'clock Monday evening the telegraph and telephone wires on the wooden poles were lying in a tangled mass on the ground, with perhaps 50 per cent of the poles lying on the ground with them. The smaller communication and control wires carried on the catenary structures held up better, but even they came down in numerous places. The stronger transmission and feeder wires did not fail at any point from the weight of the ice alone, but in one or two isolated cases they did fail because of a broken insulator, a grounding arc through snow on the insulators or a short circuit caused by smaller wires falling from above. The catenary trolley system did not fail at any point at any time.

With all communication, signal and traction control wires out of order it was of course impossible to maintain a regular schedule, so the efforts of the operating officers were expended in rounding up all the steam locomotives available and keeping as many trains on the road as facilities and safety would permit. This in itself was a hard task, as the New York division is normally operated largely by electric power, and only 25 steam freight locomotives were available. Adjacent divisions, because of delays, due to snow on the track and loss of signal and communication wires, needed all their steam locomotives, and could send none to the assistance of the New York division. The result was that only about 10 per cent of the regular number of trains were run during Tuesday and Wednesday, December 14 and 15.

All efforts on Monday and Tuesday were, first, to restore "communication" with the sectionalizing bridges so as to determine the extent and location of the trouble and, second, to get the "control" wires through to these bridges so that trolleys and feeders could be sectionalized and tested out.

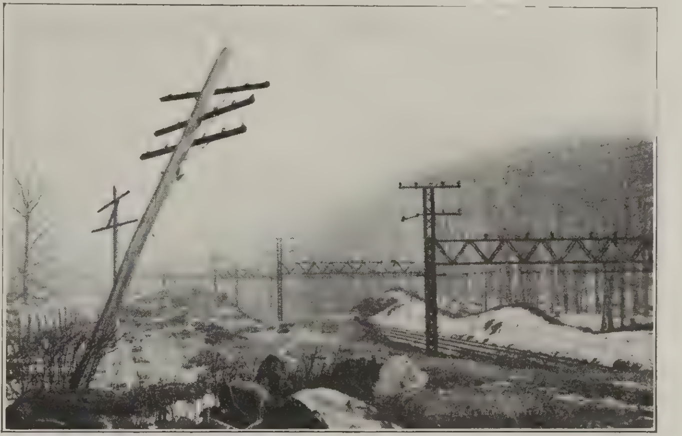


Fig. 2. Effect of the Sleet on the Wooden Pole Telegraph and Telephone Line. The Weight of Ice on the Wires also Caused One of the Steel Cross Arms on the Catenary to Bend as Shown.

It was very important to restore electric operation between New York and Stamford (the west end of the electrified zone) first, so as to take care of the heavy suburban service between these points. Under the conditions prevailing steam operation east of Stamford was more favorable for the reason that an enginehouse and a turntable are located at that point.

To do this work the electrical officers finally recruited about 150 extra linemen to assist the two regular emergency crews. These men worked day and night for 48 hours under heart-breaking conditions to get the important wires back in service. During the greater part of this time the wind was so high that the men had to wear handkerchiefs over their faces to protect themselves from the driving sleet.

Finally on Wednesday afternoon about three o'clock electric operation was started on the western end of the division. From that time on as additional sections of the signal, communication and control wires were re-established the train service was increased until Sunday, December 19, traffic conditions were again about normal.

One fact that speaks well for the forethought and concern of the railroad officers is that there were no casualties whatever during the trouble. When, from government warnings, it became apparent that a severe storm was approaching, orders were given to all concerned to use the greatest care in safeguarding passengers. With this end in view all freight trains were side-tracked early Monday afternoon.

The question naturally arises when considering this tie-up—why was electric operation impossible if the electric traction current was available at all times? The answer is that the "communication" wires and the "control" wires carried on the steel catenary structures were completely out of service.

The "communication" wires are used by the load despatcher, who is located at the central power station, to keep in touch with the tower operators at the different sectionalizing bridges along the line. The "control" wires furnish the power for operating the remote control, sectionalizing circuit-breakers which are located on the bridge and are connected in the transmission feeder and trolley circuits. Normally when a ground, broken wire or other trouble occurs the bridge operator nearest the trouble "calls up" the load despatcher over the "communication" wires and makes a report of the trouble, giving details as to its nature and location. The load despatcher immediately refers to his transmission, feeder and trolley diagrams and determines what sectionalizing switches should be opened to successfully isolate the trouble and what switches must be closed to make use of the duplicate transmission and feeder lines. His decision made, he instructs the bridge operator to operate certain switches and, if the trouble is serious, orders out the emergency crew. In such a case, after the trouble is isolated and the extra feeders, etc., are thrown into service electric operation on other parts of the system is not affected. Furthermore the emergency crew can be given definite instructions regarding the nature and location of the trouble which fact greatly minimizes the time required to make repairs. With the above facts in mind it is easy to understand how a few minor grounds or breaks in the transmission, feeder or trolley circuits could tie up the entire system if all "communication" and "control" wires and circuits were out of order. If these troubles could have been isolated and if the extra duplicate circuits could have been connected in there would have been no interference with the electric operation except that caused by the snow on the track.

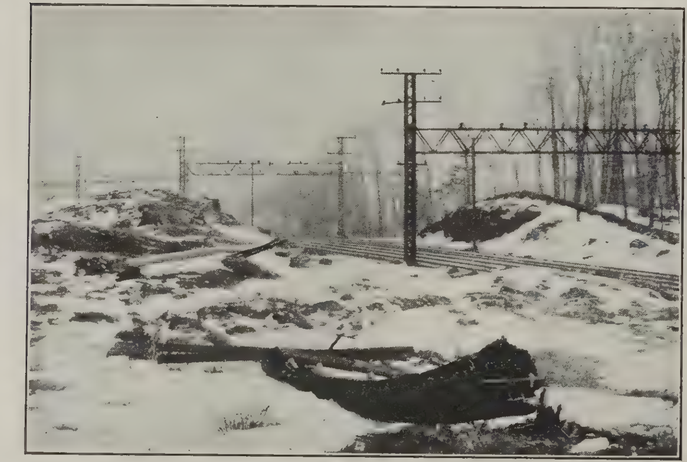


Fig. 3. A Common Sight Along the New Haven After the Severe Wind and Sleet Storm of December 13. Note.

A typical steel catenary support structure with its transmission, signal, control, communication and trolley wires is shown in Fig. 4. A table giving the B. & S. gage number and circuit reference of each wire follows:

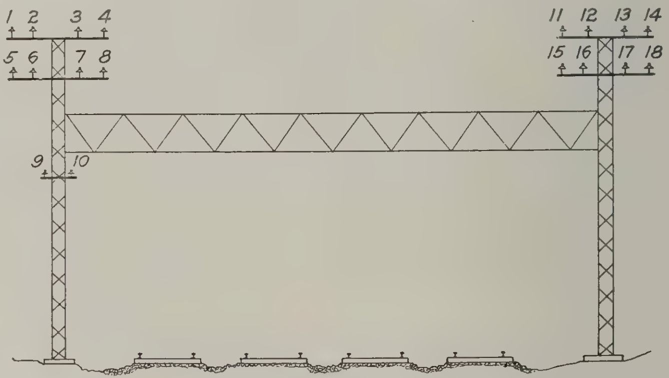


Fig. 4. Diagram of a Typical Steel Catenary Trolley Supporting Structure Used by the New Haven, Showing the Location of the Various Wires Carried on the Uprights. These Supports Are 300 Ft. Apart.

Sketch No.	Circuit.	B. & S. Gage No.
1— 2— 3—	North three-phase transmission wire	0000
4—	Feeder No. 3	0000
5— 6—	11,000 volt signal circuit	3
7—	Control No. 1	3
8—	Feeder No. 1	3
9— 10—	Telephone "Communication"	10 Copper Clad Steel
11—	Feeder No. 4	0000
12— 13— 14—	South three-phase transmission circuit	0000
15—	Feeder No. 2	0000
16—	Control No. 2	3
17— 18—	22,000 Volt Signal Circuit	3

On one section of the line an old No. 00 feeder was being used as a control wire, and it weathered the storm successfully, while, as stated above, the No. 3 control wires failed in many places. A comparison of the properties of the two sizes of control wires shows that although the ratio between their diameters is only 1.6 to 1, the relation between the tensile strength of each is 2.5 to 1.

To provide a quick temporary means of telegraph and telephone communication, the telegraph department, immediately after the storm, started to lay 30 miles of two twisted-pair wires along the right-of-way. These wires were strung on the catenary structures, on fences, along the ground, any way to get them through. Later a 20 pair cable was laid out in the same way.

The New Haven is at this time conducting a most thorough investigation of the whole tie-up, and complete facts as brought out by the investigation will be printed in a future issue.

New Facilities for Car Lighting

West Oakland Yards, S. P. Co.

J. J. Hack, Engr., Train Lighting, Heating and Ventilation

The Southern Pacific has recently installed complete facilities in its coach yards at West Oakland, Cal., for the maintenance and repair of electric train lighting equipment. The facilities include a series yard charging system and a train lighting building.

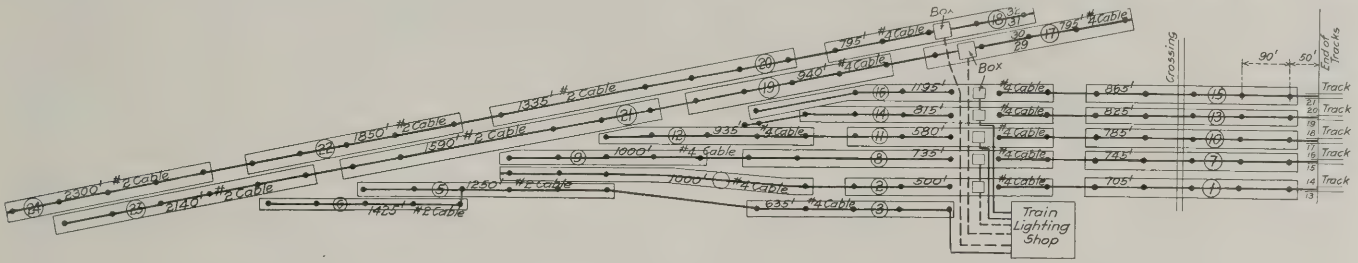


Fig. 1. Circuit Diagram of the Series Charging System, West Oakland Yards, Southern Pacific. Circuit Numbers Are Shown in Circles.

Charging System.

After a complete study of the conditions peculiar to this yard it was decided to use the series system of charging batteries. Ordinarily the constant potential system gives better results for the reason that each battery takes current according to its condition. This system is especially adaptable to yards in which most of the batteries are used in connection with axle or straight storage systems for the reason that service conditions are such that the batteries arrive in various states of charge. In this case, however, the series charging system was chosen because of its low first cost and because, considering the great length of the yard (2500 ft.), the feeders required for the constant potential system would have been excessively large and expensive.

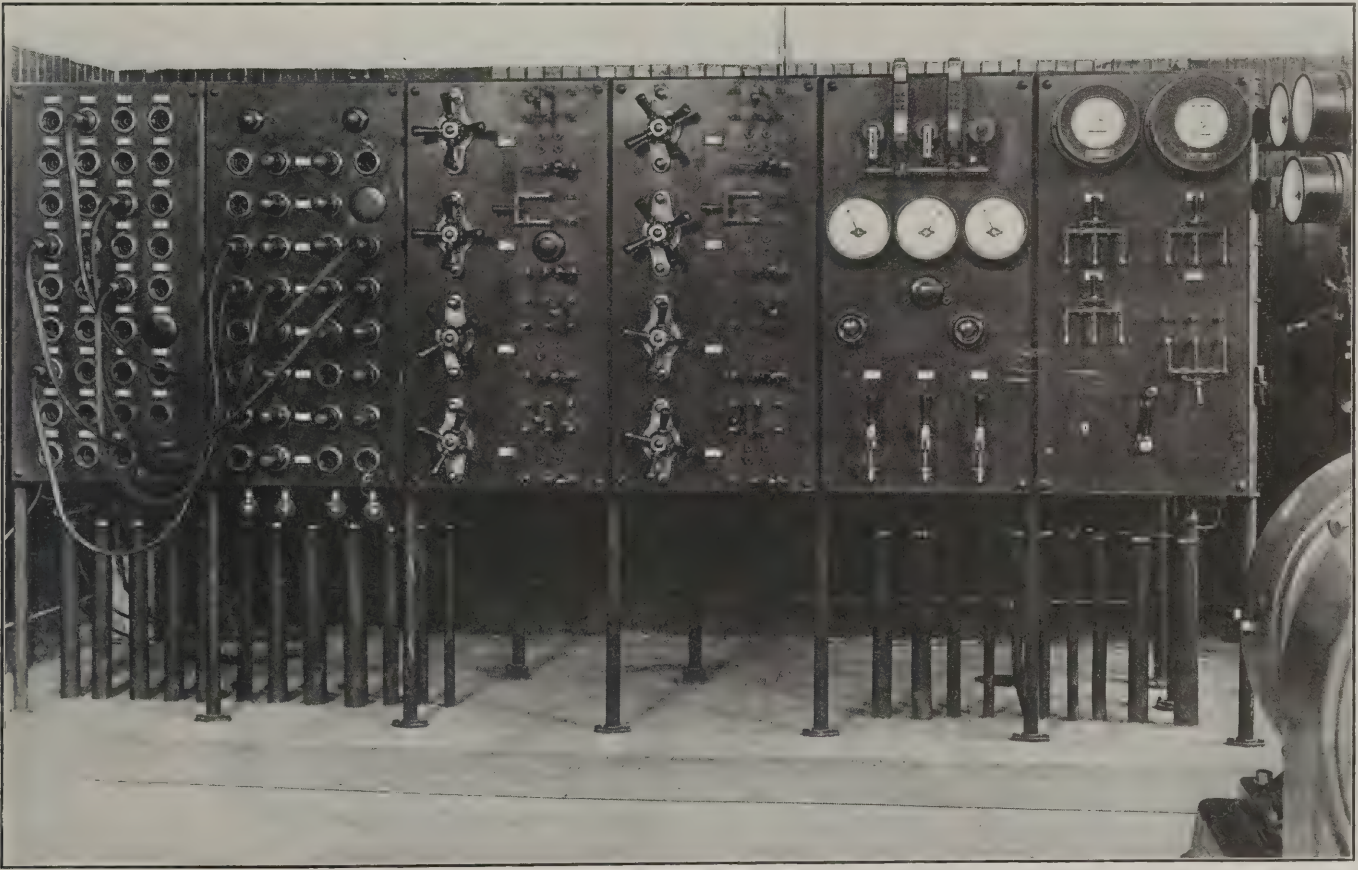


Fig. 4. Switchboard in the Generating Room, Showing the Standard Plug Receptacles at the Left, the Carbon Pile Rheostat Handles in the Center and the Generator and Power Entrance Panels at the Right.

The yard charging system consists of D. B. R. C. cables installed underground in conduit, with 140 Crouse-Hinds type U. G. C. D. outlet boxes located about 90 ft. apart between each pair of tracks. From five to seven of these outlet boxes are connected in series on each circuit. The charging current is controlled at the main switchboard by eight 75 ampere, 3,000 watt, Allen Bradley carbon pile rheostats. All conduit was laid in red-wood trunking and covered with pitch.

An interesting feature of the yard charging installation is the method of protecting the yard outlets. Each pair of outlets is covered by an A shaped frame made up of two pieces of angle section steel placed about 14 in. apart and riveted together at each end by a steel plate. The frame is rigidly set in concrete. The details of construction and application of the outlet protection frames are clearly shown in Fig. 2.

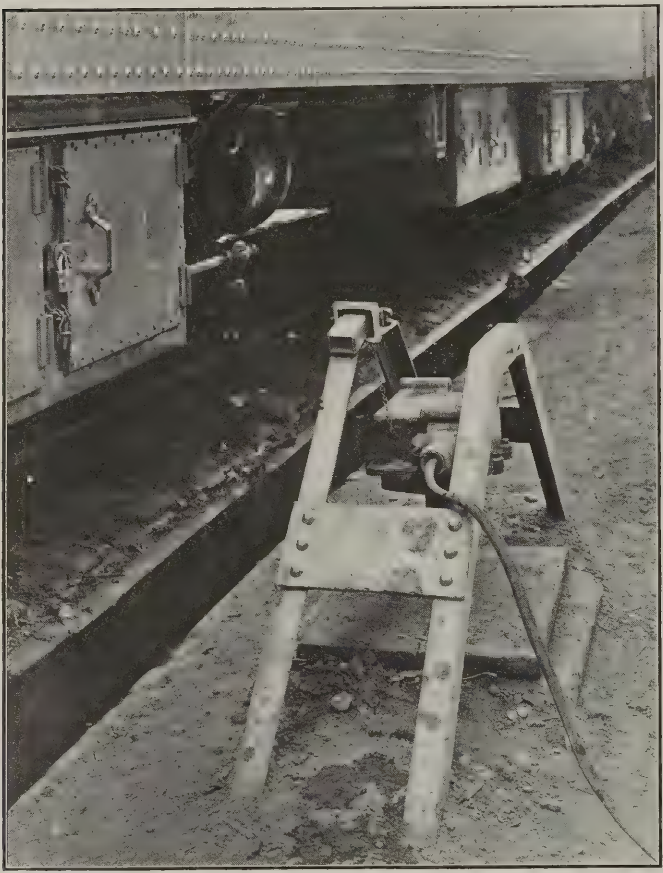


Fig. 3. Yard Charging Outlet, Showing Crouse-Hinds Type U. G. C. D. Outlet Boxes with Protecting Frame.

Another special feature of the installation is the telephones connecting with the generating room which are located at convenient points in the yard. Their purpose is to facilitate putting cars on charge by permitting easy communication between the yard and the generating room, thus saving considerable of the inspectors time.

Train Lighting Building.

The train lighting building which is located centrally at one side of the yard is a two-story brick structure, 125 ft. long by 30 ft. wide. The ground floor is divided into a 17 ft. by 30 ft. generating room and a 108 ft by 30 ft. battery room. The ceiling height of both rooms is 14 ft. The offices of the engineer of train lighting, heating and ventilation, together with a 100 ft. by 30 ft. machine shop and winding room are located on the second floor.

Single unit, enameled steel reflectors with tungsten lamps are used throughout for lighting except in the battery room where vapor proof globes with guards are used because of their acid resisting qualities.

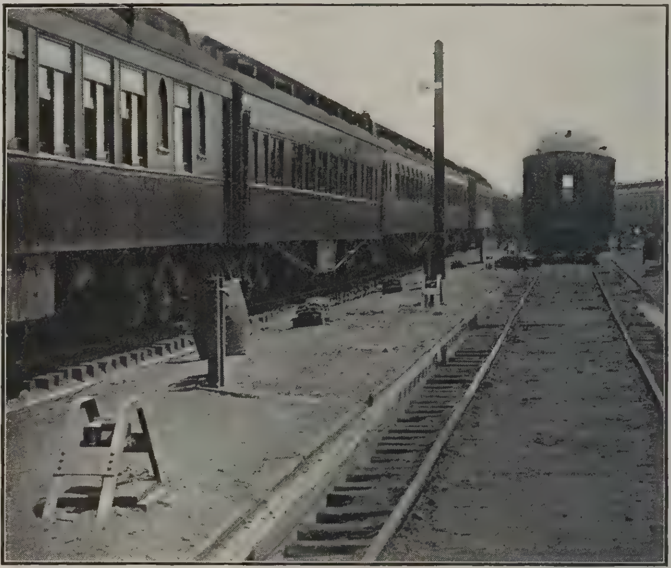


Fig. 2. One Section of the West Oakland Yards Showing Arrangement and Location of the Charging Outlets.

Generating Plant and Switch Board—The generating plant consists of a motor-generator set made up of one 75 h.p., 3 phase, 440 volt induction motor direct-connected to two 25 kw., 125 volt, 200 ampere, direct current generators, one located on each side of the motor. Three phase power at 440 volts is received from the generating plant of the railroad company.

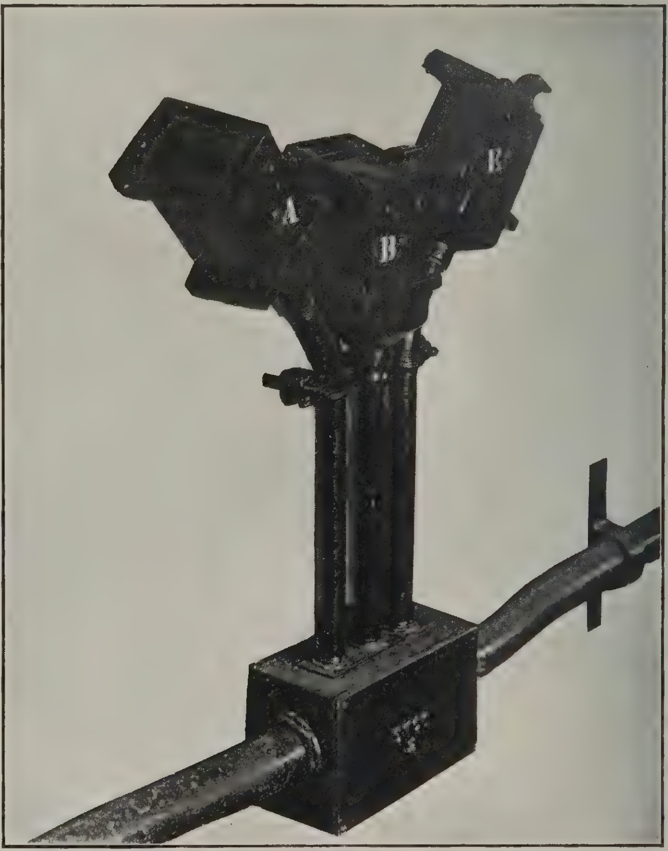


Fig. 6. Near View of Charging Outlets Used in the Battery Room.

The switch board is made up of six panels, as shown in Fig. 3. The first panel to the right is equipped with one single phase watt hour meter for lighting, one polyphase watt hour meter for power and four 3.P.S.T. knife switches for both light and power circuits. The second or generator panel is equipped with a voltmeter, ammeters, voltmeter plug receptacles and plug, field rheostats, circuit breakers and three S.P.S.T. knife switches. The three single pole switches are in the three wire 125 to 250 volt system obtained by connecting the generators in series and tapping the connection common to both. With this system both 125 and 250 volts is available for charging purposes. Each of the two central panels is equipped with four Allen Bradley rheostats, each of 75 amperes capacity and capable of dissipating 3,000 watts; four D.P.D.T knife switches for throwing either 125 or 250 volt current supply on the yard charging lines, and four S.P.D.T. knife switches for connecting the ammeters into the various yard charging circuits.

The fifth and sixth panels are equipped with Anderson Type G charging receptacles. The receptacles on the fifth panel are connected with the rheostats on the two center panels, while those on the sixth panel are connected to the yard or battery room charging circuits.

Battery Room—The battery room is a large well lighted room with a row of windows down both sides. The ceiling and the upper half of the walls are painted white while the lower half is painted black. Floor space sufficient to accommodate 60 sets of 30 volt, 300 ampere hour storage batteries is available. The special equipment in the battery room consists of a traveling crane with an air hoist, two washing benches, one large tank for distilled water, and an elevated 1,000 gallon tank for electrolyte. The tank is so arranged that batteries may be filled directly from it by means of a flexible hose.

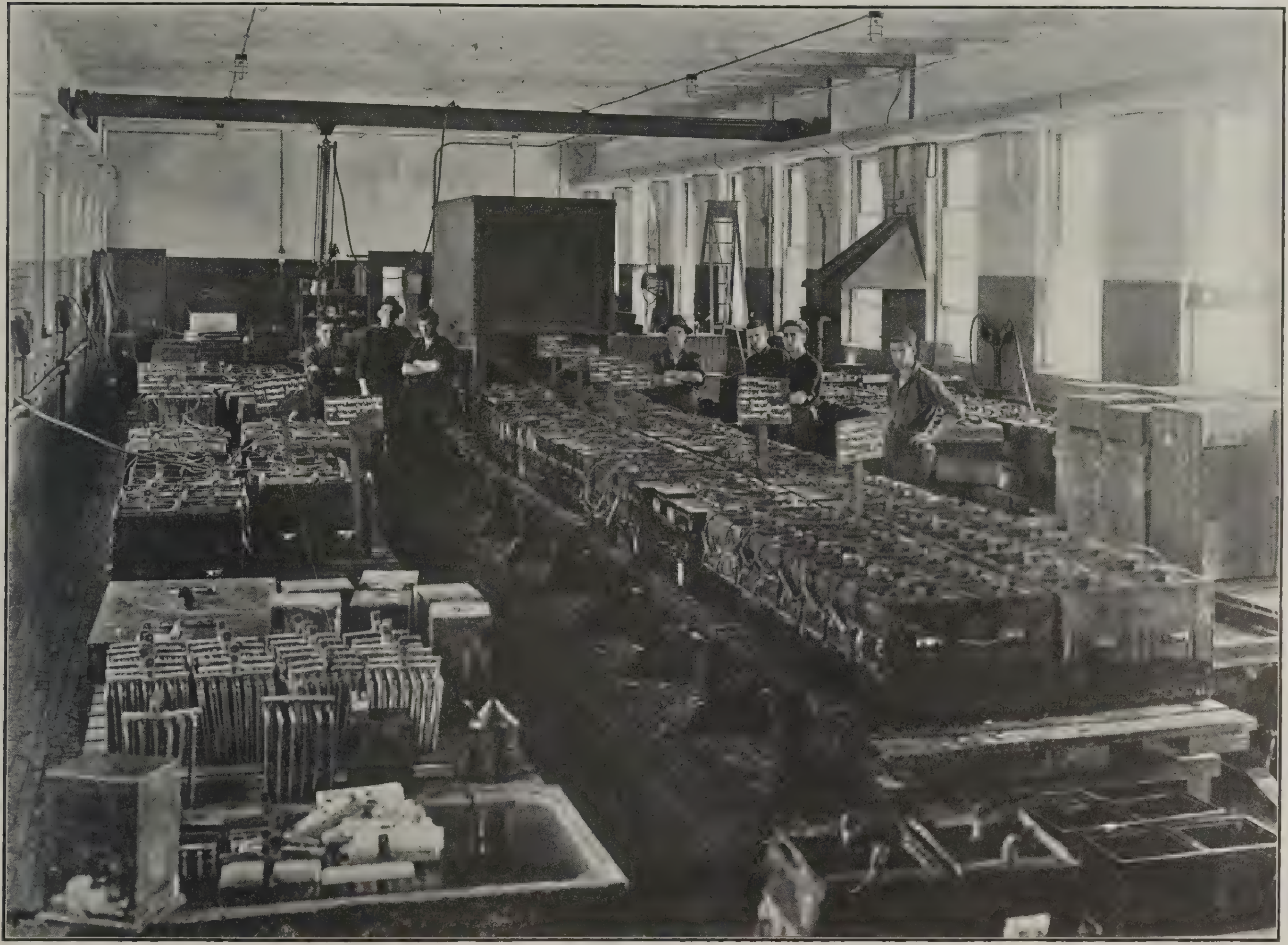


Fig. 5. Battery Room. Showing the Traveling Crane with Air Hoist. The Electrolyte Tank and the Charging Outlets Around the Walls. Note the Cheerful Effect of the White Walls and Ceiling.

Machine Shop and Winding Room—The machine shop and armature winding room occupies most of the upper floor of the train lighting building and is excellently lighted by a well distributed installation of 60 watt mazda lamps in flat cone reflectors. As in the battery room, the ceiling and walls of the shop are painted white, which materially increases the efficiency of the lighting, both day and night.

A testing switch board is provided on which the following test voltages may be obtained:

A. C.	D. C.
440 volts 3 phase 220 volts 3 phase 110 volts 3 phase 220 volts single phase 110 volts single phase	250, 125, 60, and 30 volts.

These voltages are required for testing the electric apparatus repaired in the shop, where general repair work for the west end of the line is taken care of.

Additional equipment in the machine shop and armature winding room consists of one 3-ton hydro-electric elevator, two 24 in. by 11 ft. lathes, one drill press, one emery wheel, one 10 h.p. variable speed motor for operating the shop machine tools and also for running axle light machines while under test, one lamp dipping rack, and one electric bake-oven for armature coils.

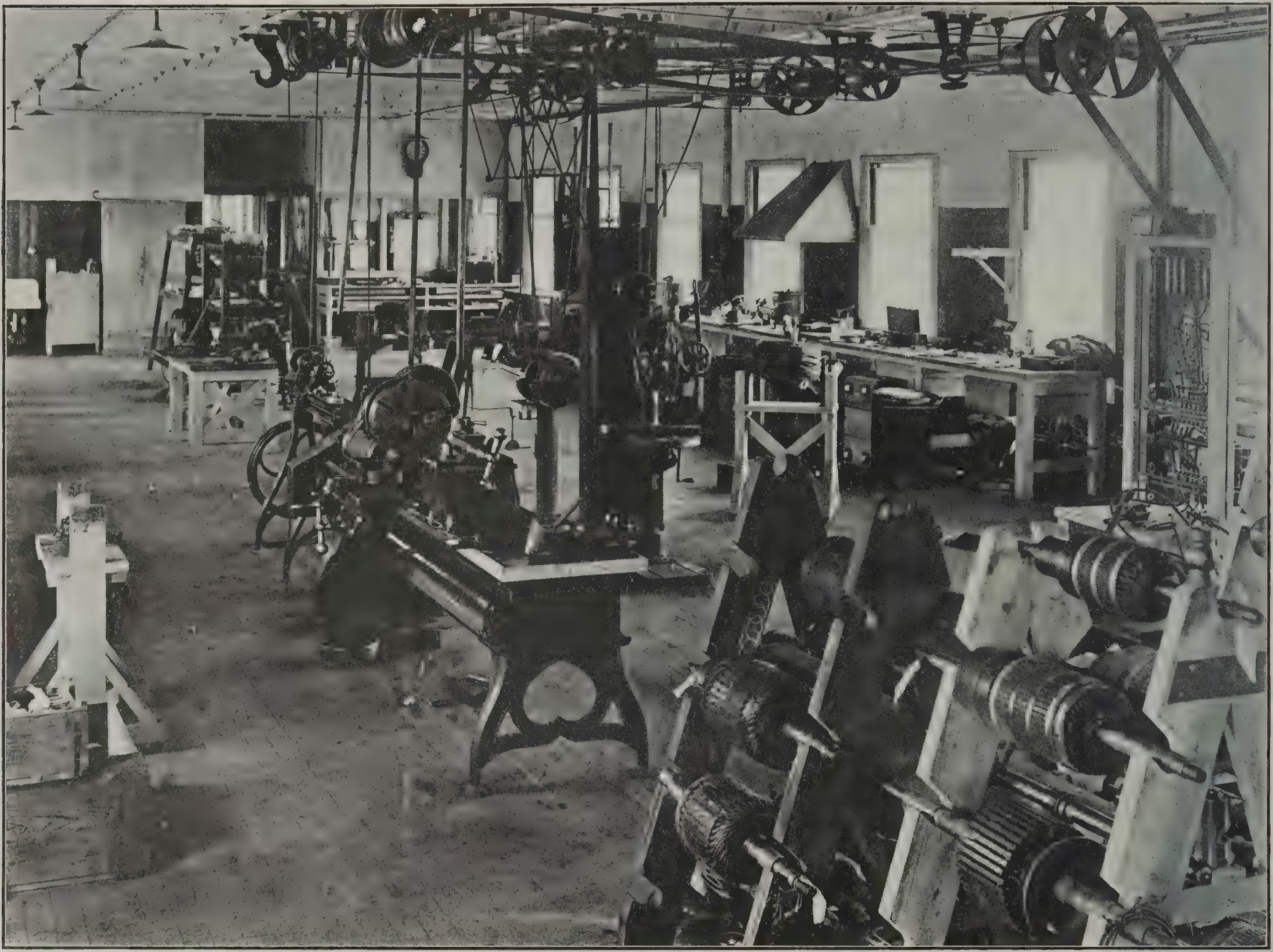


Fig. 7. Machine Shop and Winding Room. As in the Battery Room, the Walls and Ceiling Are Painted White.

Southern Pacific Six-Volt Electric Headlight Equipment

By A. H. Babcock

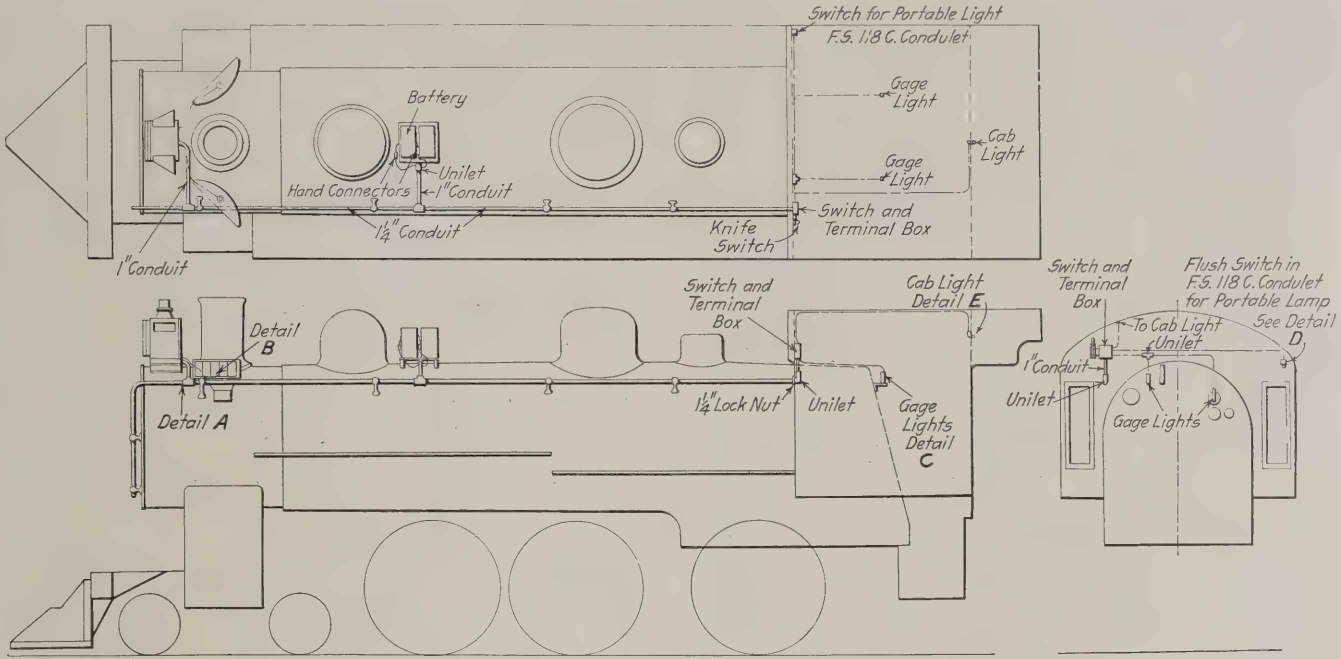
Consulting Electrical Engineer, Southern Pacific, San Francisco, Cal.

About a year and a half ago the Pacific system of the Southern Pacific replaced all its acetylene headlights with incandescent lamps of the automobile headlight type, but of larger size. The idea of automobile lighthing was carried throughout the entire installation, even to the fittings employed in the cabs and to a portable trouble lamp on a long cord, to take the place of the old smoking torch. One of the illustrations shows the type of automobile light fittings that in practice has been found satisfactory, except that under extreme summer desert temperatures, combined with high boiler temperatures, fittings that are made of molded rubber, or its equivalent, have softened. These are now being replaced with fittings of the vitrified type. The material required for making this change on each locomotive is as follows:

LIST OF MATERIAL FOR ONE LOCOMOTIVE

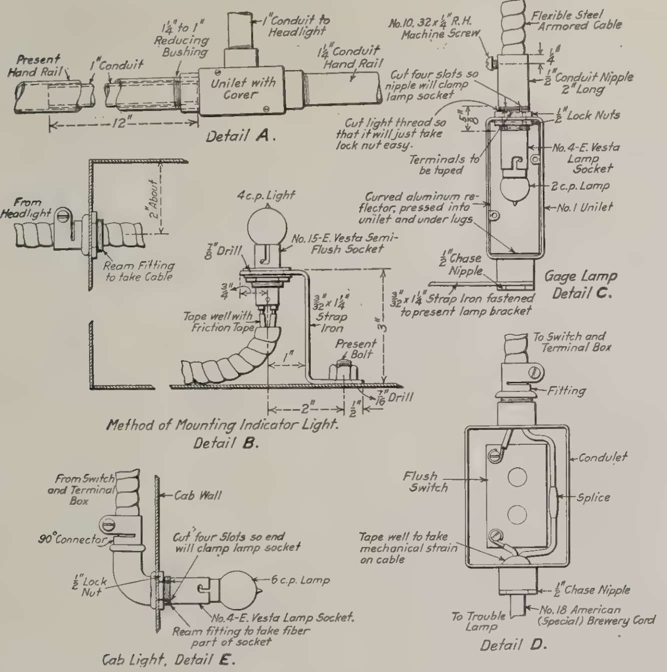
- 100 ft. No. 4 Stranded slow burning weatherproof wire. Triple braid.
- 100 ft. No. 14 Stranded slow burning weatherproof wire. Triple braid.
- 3 ft. No. 8 Stranded slow burning weatherproof wire. Triple braid.
- 10 ft. No. 18 American Special brewery cord. Two-conductor.
- 50 ft. No. 14 Type Bx, twin conductor, flexible armored
- 30 ft. 1¼-inch Economy (enameled) conduit.
- 10 ft. 1-inch Economy (enameled) conduit.
- 1 ft. ½-inch Economy (enameled) conduit (for nipples).

2	1-inch Conduit pipe clamps.
15	¼-inch Conduit pipe clamps (for flexible cable).
1	1¼-inch Conduit locknut.
2	1-inch Conduit locknut.
10	½-inch Conduit locknut.
2	½-inch Pipe nuts.
2	1-inch T. & B. conduit bushings.
1	Cat. No. 9003, Type 3, ½-inch black enameled Unilet. A. E. Co.
1	Cat. No. 6000, blank metal cover, enameled. A. E. Co.
2	Cat. No. 3100, Type 1. ½-inch black enameled Unilet. Large size with End Knockout. No cover. A. E. Co.
1	FS118C ½-inch Condulet.
11	No. 038467 fittings for No. 14 Bx. flexible cable.



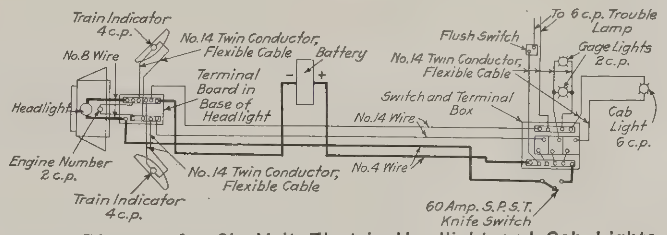
General Arrangement of Six-Volt Electric Headlight Equipment, Southern Pacific.

3	½-inch Chase nipples.
2	1¼-inch to 1-inch Pipe reducing bushings. (for Unilets).
2	Cat. No. 33014, Type 3, 1¼-inch x 1¼-inch x 1-inch black enameled Unilet. Appleton Electric Co.
1	Cat. No. 9069, Type 8, 1¼-inch elbow. A. E. Co.
3	Cat. No. 6130, blank metal covers, enameled. A. E. Co.


Present Hand Rail
1" Conduit
1¼" to 1" Reducing Bushing
1" Conduit to Headlight
1¼" Conduit Hand Rail
Unilet with Cover
12"
Detail A.
No. 10, 32 x ¼" R.H. Machine Screw
Flexible Steel Armored Cable
¼"
½" Conduit Nipple 2" Long
Cut four slots so nipple will clamp lamp socket
½" Lock Nuts
Cut light thread so that it will just take lock nut easy.
Terminals to be taped
No. 4-E. Vesta Lamp Socket
2 c.p. Lamp
Curved aluminum reflector, pressed into unilet and under lugs
No. 1 Unilet
½" Chase Nipple
Gage Lamp Detail C.
3/32" x 1¼" Strap Iron fastened to present lamp bracket
From Headlight
2" About
Ream Fitting to take Cable
4 c.p. Light
No. 15-E. Vesta Semi-Flush Socket
7/8" Drill
3/4"
Tape well with Friction Tape
3/32" x 1¼" Strap Iron
3"
Present Bolt
1"
2"
½"
7/16" Drill
Method of Mounting Indicator Light.
Detail B.
To Switch and Terminal Box
Fitting
Condulet
Flush Switch
Splice
Tape well to take mechanical strain on cable
½" Chase Nipple
No. 18 American (Special) Brewery Cord
To Trouble Lamp
Detail D.
From Switch and Terminal Box
Cab Wall
90° Connector
Cut four Slots so end will clamp lamp socket
½" Lock Nut
6 c.p. Lamp
No. 4-E. Vesta Lamp Socket.
Ream fitting to take fiber part of socket
Cab Light, Detail E.

Details of Automobile Fittings Used in Six-Volt Headlight Installation.

1	Cat. No. 9041, Type No. 1, 1-inch black enameled Unilet. A. E. Co.
1	Cat. No. 6102, All-porcelain cover. 2 wire outlets, A. E. Co.
2	No. 038453 90-deg. connectors for No. 14 Bx flexible cable.
4	No. 038569 S. P. shallow flush switches (includes 3 switches for switch and terminal box).
1	No. 034826, S. P. S. T. 60 amp. 250 volt knife switch, front connected. Terminals for No. 4 Stranded Cable.
1	No. 4022 Bryant keyless screw base mogul lamp socket for ½-inch pipe.
1	G. E. 523 mogul socket. Screw shell with spring catch only. Put in headlight case for extra lamp.



Wiring Diagram for Six-Volt Electric Headlight and Cab Lights.

3	No. 4E Vesta lamp sockets, screw terminals. Vesta Accumulator Co.
3	No. 15E Vesta plug socket, semi-flush, steel dash. V. A. Co.
1	No. 73 Vesta trouble lamp complete, except bulb and cord (includes plug at end of lamp). V. A. Co.
3	No. 037410 2 c. p. 6-Volt round auto tail light. Edison Base.
2	No. 037410 4 c.p. 6-Volt round auto tail light. Edison Base.
2	No. 037411 6 c.p. 6-Volt round auto side light. Edison Base.
1	140 c.p. 5½-volt nitrogen filled lamp with mogul base.
1	No. 56354 Westinghouse Electric & Mfg. Co. hand connector complete for battery connections.

In placing the lamps, particularly those in the cab, the principle followed has been to direct the necessary amount of light on the spot where it is needed and to cut off all extraneous light, with the result that very small lamps give entirely satisfactory illumination and the sensititveness of the engine crew's eyes is not diminished unnecessarily.

There are now 900 of these headlights in service and their performance has been remarkable. The old acetylene or arc headlight reflector can be used by simply covering the openings. A new opening should be cut in the vertex of the reflector and the incandescent lamp, with its focusing device, inserted from the rear. Lamps for six-volt circuits, especially in the sizes used for headlight purposes (108 watts), have strong and heavy filaments; consequently they may be wound into an exceedingly small cylinder not more than ⅛-in. in diameter by ⅛-in. long. This can be accurately placed in the focus of the reflector, resulting in a concentrated beam of light of great penetration. The beam candle power measures approximately 1,046,000, while the mean spherical candle power of the lamp itself is only 140. On the other hand, if a wide beam of less power is needed, as for example on crooked track in the mountains, it may be obtained by an adjustment of the focus. There is no flickering or jumping of the light as with the arc headlight; and, furthermore, while the arc lamp has a mean spherical candle power intensity of from 800 to 900, according cording to conditions of the lamp and length of arc, its beam candle power, with the same reflector, is only 165,000.

Certain manufacturers of 32-volt arc headlight outfits are using 32-volt incandescent lamps, burned up to 37 volts, in the same reflectors with the hope of securing increased illumination by forcing the candle power. On account of the fragility of the longer filament of the 32-volt lamp, this hope cannot be realized; in fact, tests show that even under these conditons the beam candle-power is less than one-half that of a six-volt lamp. Furthermore, the steam consumption of the turbo-generators designed for arc headlight purposes is from 250 to 450 lb. per hour, while that of the most recent six-volt turbo-generator for cab lighting is less than 50 lb. of steam per hour. The cost of installation is also slightly in favor of the six-volt outfit.

The portable trouble lamp was hung convenient to the engineman's head for his use when reading orders until it became evident that the portable light was also convenient around automobiles, of which our enginemen seem to have many. In fact, the practical results indicate that they found the trouble lamps more useful in the automobiles than in the engine, with the result that the trouble lamp is now being replaced with a fixed lamp over the engineman's head with a switch convenient to his hand.

For the reason that these installations were somewhat rushed, owing to legal requirements, there was not sufficient time to develop a suitable electric generator, and it was necessary to use a battery. Stationary charging stations were installed at the locomotive turning points, where the locomotives leave their exhausted batteries and take full batteries, just as they take their supplies of sand, lubricant and water.

A Code for Better Lighting*

The following code of lighting, prepared by committees of the Illuminating Engineering Society, while intended as an aid to industrial commissions and other similar bodies who are interested in enactments, rules and regulations for better lighting, is intended in equal measure for the industries themselves as a practical working guide in individual efforts to improve lighting conditions.

The code is divided into three parts; the first consists of the recommendations for legal enactment, the second gives eight rules designed to aid in the accomplishment of best results, and the third is devoted to a liberal discussion of the fundamentals of illuminating engineering involved in and the advantages obtained from better factory, mill and shop illumination. The calculation of daylight illumination and the design of windows, skylights, etc., is given careful consideration and for this reason alone the code serves as a valuable practical reference.

Part I

Article I. Daylight.—All buildings hereafter constructed must be provided with adequate window area. Awnings, window shades, diffusive or refractive glasses must be used for the purpose of improving daylight conditions or for the avoidance of excessive brilliancy wherever they are essential to these ends.

The windows, skylights, saw-tooth or other roof lighting constructions, are to be arranged with reasonably uniform bays, and the daylight openings shall be so designed and proportioned that at the darkest part of any work space, when normal exterior daylight conditions obtain, there shall be available at least a minimum intensity equal to three times the minimum intensities given in Article V for artificial light.

(NOTE: The intensity requirements for daylight are higher than those for artificial light because the physical condition of the eye during the daytime is usually such as to require a higher intensity of natural light for satisfactory vision than is required at night under ordinary well designated artificial lighting systems.)

Article II. Old buildings at present constructed and not having adequate window area, must be provided with adequate artificial light according to the following articles, so as to supplement the natural light during normal daylight hours.

Article III. All buildings, whether old or hereafter constructed, must be provided during those hours of work when natural light is insufficient or not available, with adequate artificial light according to the following articles:

Article IV.—Adequate intensity of the light must be provided for each class of work, both on a horizontal plane as well as on a vertical plane passing through the work, according to Article V. In all cases, however, glare on working surfaces is to be avoided as it tends to reduce the visual efficiency of the workmen and to increase the likelihood of accidents.

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*Code copyrighted by the Illuminating Engineering Society.

Article V. Artificial Light; *Intensity Required.*—The average illumination intensity throughout any month actually measurable in foot-candles on a horizontal plane through the work is to conform to the following table. Uncertain cases which arise as to how to classify given manufacturing operations are to be left to the judgment of a lighting expert.

Class of work	Minimum foot-candles intensity	Desirable foot-candles intensity
Storage, passageways, stairways, and the like.	0.25	0.25– 0.5
Rough manufacturing and other operations. .	1.25	1.25– 2.5
Fine manufacturing and other operations. . . .	3.50	3.5 – 6.0
Special cases of fine work.	—	10.0 –15.0

Where operations are performed on the sides of the work in hand, they shall be classified according to this table, and if the illumination is furnished from an overhead system, it shall preferably *be not less than* 50 *per cent.* of the foregoing values, when measured on a vertical surface. If the illumination is furnished by an individual lamp or by lamps close to the work, the intensity shall conform to the minimum or desirable intensities required in the foregoing table.

(NOTE: As a guide to inspectors and others, it may be stated that with modern lamps roughtly 1 candlepower per square foot produces an effective illumination of 3 foot-candles when the lamps are arranged according to the uniformly distributed overhead system, with mounting heights ranging from 12 to 16 ft. above the floor, and when the light is directed from said lamps to the work in an efficient manner. A rough idea may thus be secured of the candlepower per square foot necessary to conform to the foregoing table of intensities by taking *one-third of the intensity values given in the foregoing table.*)

Thus for fine manufacturing and other operations, the minimum foot-candle intensity is 3.5, which is approximately equal to 1.2 candlepower per square foot. The use of a portable photometer or illuminometer, however, is recommended for the determination of existing systems and all uncertain cases are finally to be established by these instruments.

Article VI. Lamps and machinery jointly, are to be so arranged as to avoid the casting of shadows over belts and other obstructions on important parts of the work, and the distribution of light from the lamps should be such as to avoid sharp contrasts of light and shade on the work.

Article VII. Inspection and regular maintenance of all lighting systems is required in spaces where work is being conducted, and in no case must the lighting devices, whether windows, lamps or auxiliaries such as globes and reflectors, be allowed to deteriorate, due either to dirt accumulations or to burned-out lamps, more than 20 per cent. below the minimum intensity values required by Article V.

Article VIII. Roadways, yards and places not usually frequented must either be provided by illumination during working hours when natural light is absent, or partly absent, to make them safe against accident to employees traversing or engaged in such places, or a convenient control or controls must be placed at the entrance to basements, stock rooms, and the like, so that a person on entering can readily turn on the lamps beforehand.

Article IX. Stairways and passageways must be provided with lamps and reflectors or shades carefully located so as to shed their light generally over the entire space or spaces involved, and in sufficient quantity to make the stairways and passages safe against accident to employees traversing or engaged in such places. For intensities see Article V.

Article X. Each working space is preferably to be illuminated by lamps mounted overhead according to the system of general lighting, in preference to individual lighting. The overhead method of lighting, besides possessing many other advantages, also tends to reduce dark spots throughout the floor area, a feature usually objectionable with the use of individual lamps. This particular Article is not an absolute requirement, but a suggestion enforceable at the discretion of a lighting expert.

Article XI. Auxiliary lighting should be provided in all large work spaces, such lamps to be in operation simultaneously with the regular lighting system, so as to be available in case the latter should become temporarily deranged.

Part II

Explanatory Rules

The foregoing articles are supplemented by the following rules, which will aid in the observance of the requirements contained in the articles; tend to reduce eye trouble and accidents; and help in the securing of favorable results in planning lighting systems.

1. Lamps should be equipped with reflectors or shades for minimizing glare and economizing light.
2. As a general plan, mount the lamps high and out of the ordinary line of vision.
3. Although the types of reflectors and shades, and reflector and shade holders or fitters on the market are numerous, it is recommended that the holder or fitter, as well as the reflector or shade be selected with reference to placing the light source at the proper point in the reflector or shade so as to eliminate glare, due to exposure of the light source, and also for the purpose of directing the light from the lamp effectively to the work.
4. Light thrown vertically downward is not the only important component of the resulting illumination. The sides of machinery, machine tools and work, as well as horizontal surfaces often require good light.
5. Control few lamps in each group so that lamps not needed may be turned off conveniently.
6. Keep windows, lamps and reflectors clean, since large losses of light result from the accumulations of dust and dirt.
7. Provide a maintenance department if the shop is large enough to warrant it, so that all the items associated with the upkeep of the lighting system may be cared for systematically.
8. Keep ceilings and upper portions of walls a light color for the purpose of rendering both natural and artificial lighting more efficient and better diffused. The lower portions of walls should be a color which is restful to the eyes, preferably a medium tint, typified by the tint known as *factory green,* or a rather dark shade of yellow. Other medium tones are also available.

Part III will be printed in subsequent numbers.

Elimination of Drop Cords in a Large Engine Terminal

The illumination of the recently completed engine facilities and shops of the Northern Pacific at Mississippi street, St. Paul, Minn., is an excellent example of modern illuminating engineering practice. The terminal consists of a 35-stall roundhouse, a power house, machine shop, blacksmith shop, tank shop, paint shop, coal dock, oil house, storehouse and a building containing the lavatory, oil-can room, locker room, bulletin room and foreman's office. The striking feature of the lighting system employed in the terminal is that all buildings are adequately and efficiently lighted without the use of a single drop cord.

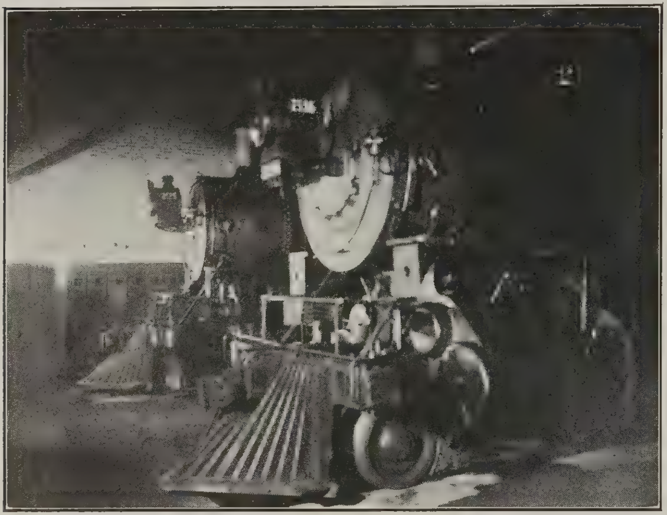

Fig. 1. A Night View Taken Without Flash in the Roundhouse. Note the Wide Angle Beam From the Wall Mounted Unity Head Lights.

The elimination of the drop cord as a source of light was made possible by using distributed illumination furnished from high candlepower tungsten lamps mounted overhead and also by using special fixtures for lighting desks, benches, steam gages, water glasses, etc. Except for yard and tunnel lighting the Unity cast-iron fixtures manufactured by the Adams & Westlake Company, of Chicago, were used throughout. These fixtures are cast in one piece from base to reflector and were selected for this installation because of their rugged and non-corrosive qualities. Special pains were taken to provide a sufficient number of extension outlets in each building so that all cases where a portable lamp would be needed were taken care of.

When the question of designing the lighting system for the terminal first came up it was decided to install some system that would not require drop cords. Past experience with this type of lighting unit had furnished ample proof of its high installation and maintenance costs, its danger as a fire hazard and, last and perhaps most important, its low illuminating efficiency. "No drop cords" was therefore adopted as a slogan and the result finally obtained is a striking example of what can be done without using this once king of lighting units.

The lighting installation in each building is the result of a careful study of the special conditions and requirements. The size and spacing of fixtures, which was given special attention, is based on careful horizontal foot-candle calculations. Proof that such procedure is justified is found in the fact that nowhere in the terminal is there either too much or too little light.

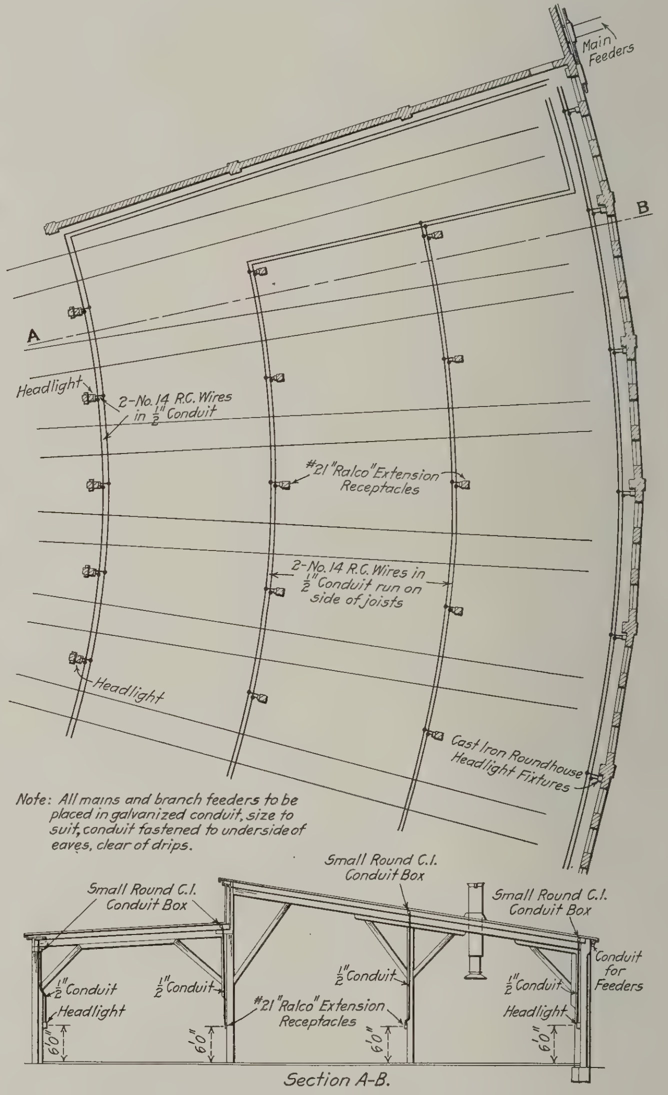
Main Feeders
B
A
Headlight
2-No. 14 R.C. Wires in $\frac{1}{2}$" Conduit
#21 "Ralco" Extension Receptacles
2-No. 14 R.C. Wires in $\frac{1}{2}$" Conduit run on side of joists
Headlight
Cast Iron Roundhouse Headlight Fixtures
Note: All mains and branch feeders to be placed in galvanized conduit, size to suit, conduit fastened to underside of eaves, clear of drips.
Small Round C.I. Conduit Box
Small Round C.I. Conduit Box
Small Round C.I. Conduit Box
$\frac{1}{2}$" Conduit
$\frac{1}{2}$" Conduit
$\frac{1}{2}$" Conduit
$\frac{1}{2}$" Conduit
Conduit for Feeders
Headlight
#21 "Ralco" Extension Receptacles
Headlight
6'0"
6'0"
6'0"
6'0"
Section A-B.

Fig. 2. Plan and Section of the Roundhouse, Showing Details of the Lighting Installation.

It will be of interest to briefly describe the important features of the lighting installation in each building.

Roundhouse

The system used was to mount a Unity roundhouse headlight fixture at each end of every stall, as shown by Fig. 1. The fixtures are mounted on the wall six feet above the floor so as to project the light into the space between the engines. The results obtained from these fixtures are especially good because of their wide diffusing angle. Another advantage is that they are absolutely gas and water tight, which means that the white enamel reflector will stay clean indefinitely. The illumination produced by this type of fixture is shown in Fig. 2.

Ralco No. 21 extension receptacles are provided on the two posts between each pair of stalls. The plug used with this type of extension outlet is practically unbreakable, being simply a piece of hardwood with a hole through the handle for the wire, and two copper contact plates screwed to the other end. The receptacle was designed especially for railroad service and consists of a standard Ralco porcelain receptacle mounted in a one-piece cast-iron case.

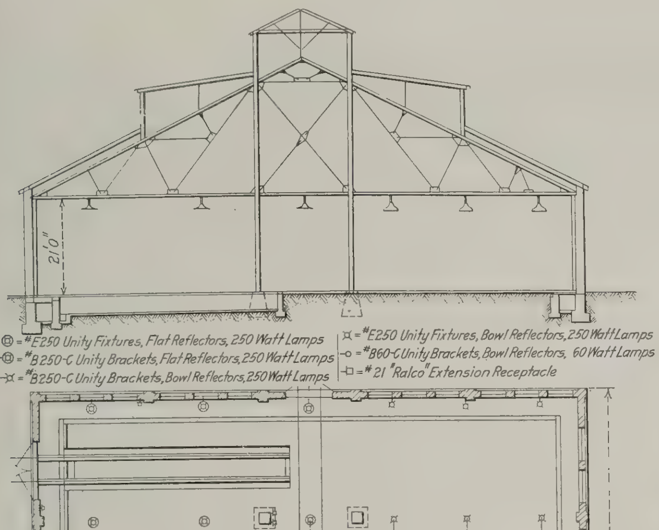
21'0"
⊚ = #E250 Unity Fixtures, Flat Reflectors, 250 Watt Lamps
-⊚ = #B250-C Unity Brackets, Flat Reflectors, 250 Watt Lamps
-¤ = #B250-C Unity Brackets, Bowl Reflectors, 250 Watt Lamps
¤ = #E250 Unity Fixtures, Bowl Reflectors, 250 Watt Lamps
-o = #B60-C Unity Brackets, Bowl Reflectors, 60 Watt Lamps
-□ = #21 "Ralco" Extension Receptacle
18'0"
16'0"
16'0"
24'0"
23'0"
Tool Room
Office (Above)
165'0"
11'0"
11'0"
11'0"
16'6"
120'0"

Fig. 3. Section and Plan of the Machine Shop, Showing the Location and Size of the Lighting Units.

In the drop pit section of the roundhouse 250-watt flat Unity reflector sockets and brackets are mounted 20 ft. above the floor and between the pits on 25 ft. centers. The flat reflectors were used so that the tops of the locomotives would be well illuminated. Ralco extension receptacles were also provided in the drop pit section. The drop pits themselves are lighted by two Unity headlights placed one at each end in beveled recesses made when the concrete was poured.

The drop pits are also provided with a Ralco No. 21 extension receptacle.

Machine Shop

The scheme followed in the general lighting of the machine shop was to hang 250-watt Unity reflector sockets over head, 20 ft. from the floor. In the machine tool bay deep bowl reflectors were used and were hung in three rows, 16 ft. apart with 22 ft. between units. In the erecting bay flat reflectors were used and were hung in three rows, 23 ft. and 24 ft. apart, with 22 ft. between units. In both bays the end fixture in each row is a 250-watt Unity bracket fixture fastened to the wall. Bowl fixtures were used in the machine bay to shield the lamp filiments as much as possible and to concentrate the light on the working plane. Flat fixtures were necessary in the erecting bay to provide proper illumination on the tops of the locomotives. The location of fixtures in the machine shop is shown in Fig. 3 and a night view of this shop taken without flash light is shown in Fig. 4.

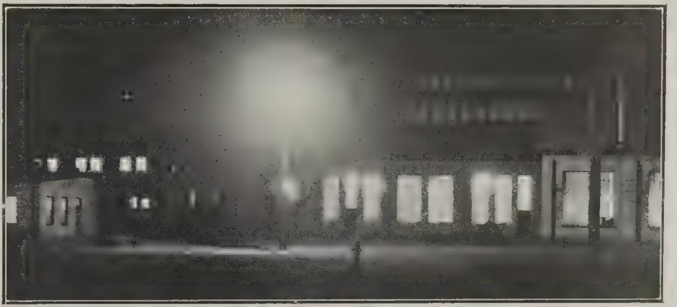

Fig. 4. Night View of the Yard Near the Machine Shop, Showing the Illumination From One of the 1,000-Watt Mazda "C" Lamps in a Maxolite Reflector.

The work benches along the wall of the machine bay were lighted by 60-watt Unity brackets with bowl reflectors, each provided with a rotary snap switch in a condulet. These fixtures are plainly seen at the extreme right of Fig. 4. The general lighting effect in this, as well as in other shops, is greatly improved by the white walls.

Powerhouse

The powerhouse consisted essentially of a 57 ft. by 46 ft. engine room and a 48 ft. by 46 ft. boiler room. The bottom of the roof trusses are 20 ft. above the floor in each case.

The engine room is lighted by a double row of 250-watt Unity bowl ceiling fixtures mounted on the bottom of the two wooden trusses. The rows are 12 ft. apart and the nine units are staggered on 10 ft. centers. It had been the practice formerly to use two 1,000-watt fixtures in engine rooms of this size, but although such a system costs less the shadows produced around the generating units, air compressors, etc., were objectionable. The use of a greater number of smaller size units makes a more satisfactory installation.

A special feature of the lighting installation in the engine room is the lamp sockets and Hubbel attachment plug receptacles in type K condulets which are located on the engine frames. Both generating units are equipped with an automatic oiling system and the 40-watt lamp located near the main bearing enables the engineer easily to see the oil drips. The attachment plug receptacle is used to plug in an extension cord when making adjustments or repairs on the engines.

The pump pit which is located at one side of the engine room is well lighted from the main engine room units but at one end under a slab of concrete, forming a bridge between the door and the engine room proper, four 60-watt lamps are used in type V189 condulets. The pump pit is also provided with two Hubbel attachment receptacles in type K condulets. It should be mentioned that the Hubbel receptacles were used in all cases where the extension cord would not be subjected to extremely hard service, such as in the power house, oil house, storeroom, etc. The heavier and more rugged Ralco receptacles and plugs were used in places where the Hubbel would not stand up, such as in the roundhouse, erecting bay of the machine shop, etc.

In the boiler room two 250-watt deep bowl Unity reflector sockets are hung over the space between the boiler fronts and the coal bunkers, at a height of 18 ft. Around the sides and behind the boilers 40-watt lamps in outlet boxes have been provided together with Hubbel attachment plug receptacles in type K condulets. Bracket fixtures were not used because when cleaning tubes, etc., it is desirable to have light well distributed over the entire side and back of the boilers. To provide the necessary light above the boilers, two 40-watt lamps in outlet boxes with wall guards were mounted on the lower member of the roof trusses. The water glasses and steam gages are lighted by special Unity gage lamps permanently fastened in position by wrought iron straps bolted to the water column or to the boiler proper.

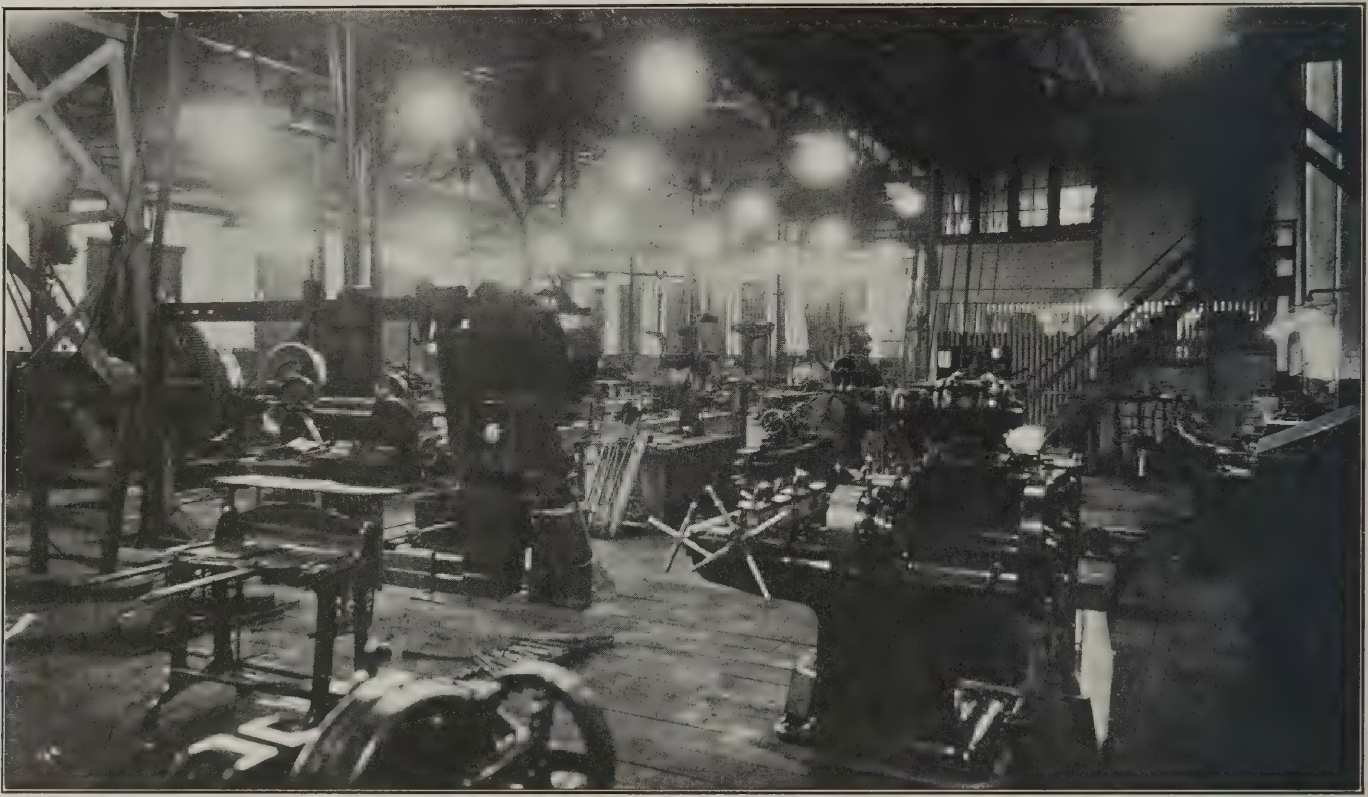

Fig. 6. Night View of the Machine Shop, Taken Without Flash. Note the Bench Lighting at the Right, and the Cheerful Effect of the White Walls.

Blacksmith Shop

The blacksmith shop is a one-room brick building 90 ft. long by 60 ft. wide with a steel truss supported roof.

The lighting plan of this building is similar to that of the machine shop, eight 250-watt deep bowl Unity reflector sockets are supported from the roof trusses in three rows, 15 ft. apart. The lighting units are staggered so that three of them are in the outside rows and two in the center, the distance between any two fixtures being 20 ft. The mounting height is 15 ft. The work benches are provided with 60-watt deep bowl Unity brackets, located about 10 ft. apart and 7 ft. from the floor. The illumination obtained from such an installation is excellent. The floor, tools and benches are well lighted without any perceptible glare, and there is a marked absence of shadows due to the proper distribution of the units. The watts per square foot (2.7) in this building is rather high, but not too high considering the gas and smoke usually found in a blacksmith shop with the resultant deterioration of fixture efficiency.

Tank Shop

The tank and paint shops are in one brick building, similar to the machine shop, 120 ft. long by 100 ft. wide outside and are separated by brick partitions.

The tank shop is 96 ft. by 67 ft. inside and is lighted by twenty 250-watt lamps in flat reflectors hung in four rows 24 ft. apart with 20 ft. between units. The two outside rows are brackets fastened to the brick walls while the two inside rows are reflector sockets suspended from the roof trusses. The paint shop has a similar installation except that the 15 units used are in three rows 22 ft. apart. There are six Ralco No. 21 extension outlets in the tank shop and four in the paint shop. Flat reflectors were used in both shops so as to properly light the tops of the engines and tenders.

Sand House

The sand house is a wooden building 86 ft. long and 22 ft. wide, divided into a 17 ft. by 22 ft. stove room and a 69 ft. by 22 ft. storage room. The stove room is lighted by two and the storage bins by four 60-watt deep bowl Unity ceiling fixtures mounted 12 ft. above the floor.

Oil House

The oil house is a brick and concrete structure with one story and a basement and is 47 ft. long by 27 ft. wide inside. The lighting installation on the main floor consists of six 100-watt Unity bowl ceiling fixtures in two rows 9 ft. apart with 15 ft. between units; mounting height of all units, 10 ft. These fixtures were placed over 4-in. outlet boxes which were embedded in the concrete ceiling beams. The basement, which contains the oil tanks, is lighted by four 40-watt lamps in type V189C condulets. A 100-watt Unity bracket with flat reflector and with a base threaded to take a ½-in. conduit coming through the wall is placed over each door on the outside.

Storeroom

The storeroom is a two-story brick building with a full-sized basement. Part of the main floor is occupied by the master mechanic's office, but the greater part of the floor is taken up by the storeroom proper, which consists of a shipping room and a room containing 14 tiers of material racks or shelves. These tiers are 6 ft. apart and 20 ft. long by 3 ft. wide by 10 ft. 8 in. high and are lighted by two 100-watt Unity ceiling fixtures with bowl reflectors between each pair of tiers. The mounting height of these fixtures is 11 ft. and they are placed on 10-ft. centers. The main aisle between the tiers of shelves is 60 ft. long and is lighted by two similar fixtures on 30-ft. centers. The results obtained by the use of ceiling fixtures for lighting these shelves exceeded the expectations of the designers of the installation. It was thought that this was one place where drop cords were absolutely necessary to get sufficient light into the individual compartments formed by the shelves and the vertical partitions. The perfect diffusion and lack of glare which characterizes the present system, however, shows that it is better in every way than the drop cord system, including safety and economy.

The shipping room and the offices are lighted by 100-watt ceiling fixtures with 60-watt bracket lamps mounted at convenient places on the walls for individual desk lighting where shadows from the overhead lighting would be objectionable. The second floor and the basement are both large open spaces 117 ft. long by 27 ft. wide used for storage only. Their lighting installations are identical, each consisting of eighteen 100-watt Unity bowl ceiling fixtures, mounted 11 ft. above the floor and placed in three rows of six units each, 16 ft. between rows and 8 ft. between units. Such an installation is equivalent to .58 watts per square foot, and produces an average illumination of about 1.75 foot candles. This is not too high considering that in such a storeroom it is necessary to read labels and other marks on boxes, name plates on machinery, etc. Ordinarily such places are not sufficiently lighted and many fires are caused by the careless use of lighted matches. Conforming to a standard adhered to throughout, a flexible switch control was provided so that all lights not actually needed could be turned out.

Foreman's Office Building

The scheme of lighting followed here was to use 100 and 150-watt ceiling fixtures throughout. Flat reflectors were used in the lavatory and in the bulletin room while bowl reflectors were used in the locker room and offices.

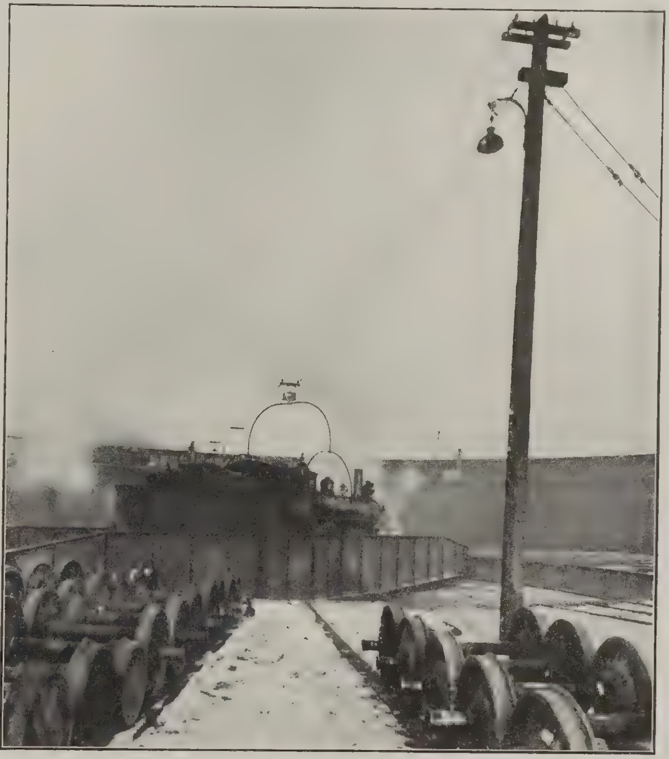

Fig. 6. View of the Roundhouse Circle, Showing Two of the 1,000-Watt Maxalite Yard Lighting Fixtures, One on the Pole and One on the Steel Cable Suspension System, Which Also Supports the Overhead Feeders for the Turntable.

Yard Lighting

The cinder pit, spaces between buildings and the roundhouse circle were amply lighted by 1,000-watt Mazda C lamps in Maxolite enameled steel reflectors, No. 7825, mounted 30 ft. above the ground on Cutter pole fixtures. A night view near the machine shop showing the illumination from one of these units is shown in Fig. 5.

A view of the roundhouse circle is shown in Fig. 6. Two of the 1000-watt yard-lighting fixtures are provided here as shown. This view also shows the novel overhead entrance of the turntable feeders.

Shop Motor Section

Feeder Voltage Regulators

J. H. Wickman*

XIV

The modern practice of installing large generating units in central stations and distributing stations necessitates the installation of individual feeder regulators to keep the correct voltage on feeders which have their peak loads at different times. The several different kinds of feeder regulators are classified as induction type and switch type, single-phase and polyphase, hand operated and automatically operated. The regulators described in this discussion will be of the General Electric manufacture.

These feeder regulators are variable ratio transformers, or compensators, which have two separate windings, primary and secondary, connected respectively across and in series with the feeder to be controlled. With the exception of a very small loss, the product of volts and amperes on both sides of the regulator is equal. For example: If there were 100 volts on the feeder that showed 100 amperes at the switch board, assuming there was no loss in the regulator and assuming that it had a 10 per cent boosting and 10 per cent lowering range, the voltage on the feeder side of the regulator in its maximum boosting position would be 110 volts and the current would be 90.901 amperes, while the voltage on the feeder side, with the regulator in its maximum lowering position, would be 90 volts and the current, 111.11 amperes.

Induction Regulators.

The induction regulator is designed for use in one, two, three and six-phase circuits, and although used formerly for the regulation of voltage on the rotary converter, it has been used more recently for the regulation of voltage on lighting and power feeders. The poly-phase type was formerly used on three-phase work, but where there is a four-wire, three-phase system, it is better practice to use single-phase regulators by placing one on each of the three main wires.

The induction regulator gives a smooth variation in voltage and avoids any necessity of switching. This type is preferable to the step-by-step regulator which was once in general use, and which varied the voltage by cutting in and out sections of the transformer windings. The induction regulator is a special type of transformer in which the mutual inductance may be varied by mechanically rotating the primary winding with reference to the secondary winding. The primary winding is connected across the feeder circuit, while the secondary winding is connected in series with the feeder circuit. Single-phase induction regulators have a secondary induced voltage whose value depends on the relative angular position of the primary and secondary coils, but which is always in phase with the primary voltage. The feeder voltage is therefore always equal to the arithmetical sum or difference of the primary and secondary voltages. Poly-phase induction regulators have a constant secondary induced voltage which differs in phase from the primary voltage by an amount depending on the angular relation between the primary and secondary windings. The feeder voltage is then the vector sum of the primary and secondary voltages.

The two windings are arranged on separate, circular, concentric sheet iron cores, one of which is stationary and the other arranged so that it may be partially rotated within the former. The series or secondary winding is arranged in slots on the inside circumference of the stationary core, and the shunt or primary winding in similar slots on the outside circumference of the movable core and the variation in the feeder voltage produced by the regulator is entirely due to the change in the relative angular positions of these cores.

The winding of both primary and secondary cores are in effect polar windings. When a given pole of the primary is opposite a similar pole of the secondary, the regulator will boost the line voltage, but will lower it if a dissimilar pole is opposite. The change from boost to lower is gradual, because a given primary pole is rotated through the angle between a similar and a dissimilar pole of the secondary. The single-phase and poly-phase methods of accomplishing this are radically different, therefore each will be taken up separately.

Single-Phase Regulators.

The arrangement of the primary and secondary cores and windings is shown in Fig. 36, in diagrammatic form. As there is only one excitation winding, the magnetizing flux is an alternating one and its direction is always parallel to that diameter of the movable core which passes through the center of the exciting coils, but its direction may be varied with respect to the stationary core and, consequently, with respect to the stationary or series winding.

With the armature in such a relation to the field that the primary windings induce a flux opposite to that induced by the secondary, the voltage induced by the primary in the secondary is added directly to the line voltage, but is subtracted when the direction of the flux is the same; the complete range being obtained by rotating the armature through an angle of 180 degrees. As the core is rotated gradually, the relative direction of the primary flux and, consequently, the amount forced through the secondary coils, is similarly varied and produces a gradually varying potential in the secondary from the maximum positive through zero to the maximum negative value. The induced potential is, however, always in phase with

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* Foreman Electrician Shops, Illinois Central, Chicago.

the excitation and is added directly to or subtracted from the line voltage.

The primary or rotating core contains two windings —the active or shunt winding connected across the line and the second winding, short-circuited on itself and arranged at right angles to the shunt winding. The object of this short-circuited winding is to decrease the reactance of the regulator, as follows: As the primary and the short-circuited windings are both on the movable core and permanently fixed at right angles to each other, the flux generated by the primary winding passes through either side of the short-circuited coil, and is not affected by it in any way whatever, for as long as no flux passes through this coil there is no current flowing through it. This condition is, however, only true when the armature is in the maximum boost or maximum lowering position with current flowing in the series winding and in any position of the armature with no current in the secondary.

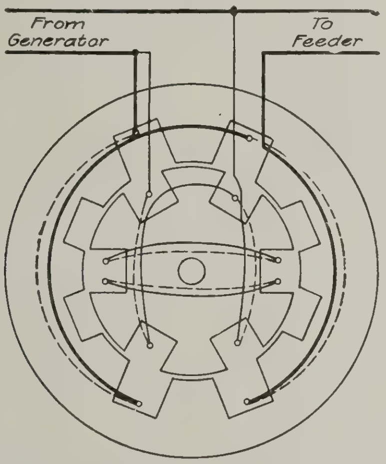

Fig. 36. Schematic Diagram Showing Arrangement of the Primary and Secondary Cores and Windings, and Also the Short-Circuited Primary Winding of a Single-Phase Feeder Voltage Regulator.

With the armature in the neutral, or no boost or no lower position, the flux generated by the current in the secondary winding passes equally on either side of the primary coils, which cannot, therefore, neutralize the flux generated by the secondary.

If the primary were not provided with a short-circuited winding, and were rotated from either maximum position so as to reduce the primary flux passing through the secondary, and if the line current remained constant, a gradual increasing potential would be required to force the current through the series winding, and a correspondingly increasing flux would have to be generated. This voltage would become a maximum with the armature in the neutral position, due to the fact that in this position the shunt coils are at right angles to the series coils and, therefore, entirely out of inductive relation to them. The current in the secondary, therefore, would act as a magnetizing current, and a considerable part of the line voltage would have to be used to force the current through these coils. The voltage so absorbed would be at right angles to the line voltage and the result would be a poor power-factor on the feeder.

The short-circuited winding on the armature, however, which is in a direct inductive relation to the series coils when the armature is in the neutral position, acts as a short circuit on the secondary winding and, thereby, reduces the voltage necessary to force full load current through this winding to very little more than that represented by the resistance drop across the secondary and short-circuited windings. This short-circuiting of the secondary is gradual, from zero in the maximum boosting position of the regulator to the maximum short-circuiting in the neutral, so that by the combined effect of the primary and the short-circuited coils, the reactance of the secondary is kept to within reasonable limits, and produces no appreciable effect on the line.

The operation of the short-circuited coils does not increase the losses in the regulator, but rather tends to keep them constant for a given secondary current. In rotating the armature from either maximum to the neutral position, the current in the primary diminishes as the current in the short-circuited coil increases, so that the total ampere turns of the primary plus the ampere turns of the short-circuited coils are always approximately equal to the ampere turns of the secondary.

The exact arrangements of punchings and windings for a small type of induction regulator is shown in detail in Fig. 36, although the number of slots and comparative number of coils increases for larger sizes of regulators.

Poly-phase Regulators.

In the poly-phase regulator the excitation is produced by the combined action of shunt windings connected across separate phases of the system. The shunt windings for different phases must be identical in every way and arranged so that the various windings magnetize a given pole of the regulator in the same direction; that is, each pole of the regulator is wound with as many distinct and separate windings as there are phases, and these windings are connected to the line in the same order as similar windings on the generator. The magnetizing flux produced has a practically constant value, but does not have a constant direction. The magnetic field is a rotating one, not an alternating one as in the single-phase type and the speed of rotation of the field per pole is the same as that of the generator.

All the slots on the circumference of a poly-phase regulator are filled with the windings of the various phases symmetrically arranged. The secondary or series windings is similarly arranged on the inside circumference of the stationary core; and the voltage produced in the secondary is due to the rotation of the flux produced by the combined action of the primaries. The voltages generated in the series winding of the various phases are, therefore, of the same value, and are constant for all positions of the armature, and the variation of the line voltage produced by the regulator is due to a phase displacement.

Due to the rotation of a similar field produced by the current in the series coils, the current in the shunt windings is constant, regardless of the position of the armature, for a given line current, and the current in the shunt windings is taken from the line or delivered back into the system as the armature is rotated from maximum boost to maximum lower in the same phase relation as represented by the secondary voltage.

This condition is due to the fact that the current in the series winding determines the direction of current in the shunt winding in the same way that the voltage across the shunt winding determines the direction of the voltage in the series or secondary winding.

With the arrangement of shunt windings necessary in the poly-phase regulator, the impedence of the device is, therefore, small without the use of the short-circuited coil as required in the single-phase device, and the total ampere turns of the primary are equal to the total ampere turns of the secondary. This accounts for the current in the shunt winding being out of phase with that in the series coils in any other than the maximum boost or lower positions.

Design.

The cases that enclose the cores and windings are similar to those of transformers and the manner of cooling these regulators is carried out in the same way as with transformers. Where cheap water is available, good cooling effect can be obtained by using a water-cooled type of regulator, which is filled with transil oil and is equipped with a water coil. The heat is transmitted through the oil to the water coil, where it is carried off by the flow of water. The oil is an electric insulator and also a heat conductor.

The power factor of the induction regulator is not as high as some types of regulators where parts of the windings are cut out and in for varying the voltage, but the power factor of the feeder is lowered very little by having the regulator connected to it.

The efficiency of any piece of apparatus is the ratio of its output to its input and the output equals the input minus the losses. The only losses in a feeder regulator are the resistance loss of the windings and the excitation current which together amount to from 3 to 7 per cent of the kilowatt capacity of the regulator. The efficiency of these regulators would then vary from 93 to 97 per cent, depending on their capacity.

Poly-phase Windings.

Poly-phase induction regulators are wound with a distributed type of winding, such as used on practically all alternating current motors and generators. There are, however, more difficulties to be met with in the winding of the regulator than with the induction motor, because each winding of the stator and rotor of the regulator must be considered by itself, also the rotor must have a definite angular position relative to the stator in order that the mechanical maximum and minimum positions will coincide with the electrical positions.

A three-phase regulator usually has the primary winding placed on the rotor and may be connected either delta or star. There are three separate series windings usually placed on the stator, with both ends of the coils brought out so that all connections can be made from the outside of the case. Since the voltage impressed on the shunt windings produces a rotating magnetic field, and since this magnetic field also cuts the conductors composing the series winding, a voltage of practically constant value will be generated in each of the three series coils regardless of the angular position of the series coils.

The phase direction of the voltage in each of the series coils will vary, however, depending on the relative angular position of the stator and rotor. Since the series coils are in series with the line, whatever voltage is induced in these coils will be added vectorily to the line voltage. If the respective primary and secondary voltages are in phase and in the same direction, a maximum voltage will be obtained on the feeder side of the regulator, but if the respective voltages are in phase, but in the opposite direction, a minimum voltage will be obtained. In any other position the voltages will be between the two extremes.

Alternating Currents

Williard Doud*

Article No. 9

Transformers

One of the principal reasons for the extensive use of alternating current, in addition to the simplicity of the generating and current using apparatus, is the facility with which its voltage may be changed to suit varying conditions of transmission. The apparatus in general use for changing alternating current voltage is an ideally simple and rugged piece of apparatus called a transformer. For the purpose of this article, but one transformer will be considered, the constant potential type, in general use on lighting and power circuits for the transformation of voltage and in which there are no moving parts.

A transformer generally consists of an iron core completely encircled by the turns of one or more insulated copper wire coils which may be wound upon it. Any number of coils may be wound on a single iron core to suit required conditions. Two coils are necessary to make a complete transformer; the one which is connected to the receiving circuit being called the primary coil or winding and the coil connected to the delivering circuit is known as the secondary coil or winding. The coils or windings are completely insulated from each other and the iron core, the character of the insulation depending on the difference between the primary and secondary voltages. The action of the transformer may be briefly described as follows: If an insulated coil wound on an iron core is excited by an alternating current, an alternating field will be produced in the core. The effect of this field is to generate or induce an electromotive force in every turn of wire wound around the core, whether it is an independent coil or a series of separate coils each connected to its individual circuit. The primary and secondary electro-motive forces or voltages are proportional to the number of turns in the primary and secondary coils. For example, if there are 100 turns in the primary coil and 1,000 in the secondary and an alternating current of 100 volts is impressed on the primary coil, the secondary coil will deliver a current having a voltage or pressure of 1,000 volts. Similarly, if an electro-motive force of 1,000 volts is impressed on the core having 1,000 turns a voltage of 100 will be produced in the coil having 100 turns.

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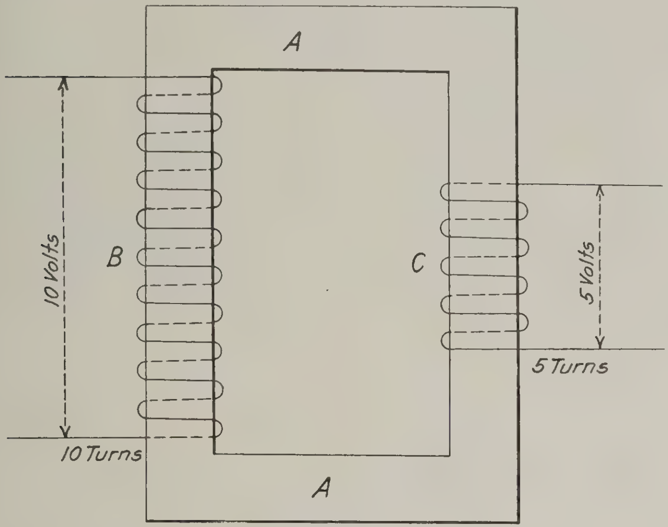


Fig. 1. Diagram of Transformer with One Primary and One Secondary Coil.

While the above is a simple statement of the action of a transformer, the laws of turns and voltages will be dwelt upon more fully in order to make clear some of the more complicated actions which can not be described clearly in a general statement. When the core of a transformer is excited by connection to an alternating current circuit, the flux generated induces an electro-motive force in every turn of wire about the core, whether it is an independent coil or the same coil in which the voltage was impressed from the outside. This electro-motive force is the result of a combination of several electro-motive forces and practically is equal to the primary electro-motive force divided by the number of turns on the primary coil. It is almost directly opposed in phase to the primary electro-motive force; that is, when the outside electro-motive force has a maximum positive value, the force which is generated in each coil wound on the core has nearly equal negative value. The impressed and induced electro-motive forces are so nearly equal in value and opposite in relation that the impressed electro-motive force in the primary coil and the induced electro-motive force in the secondary coil just about balance each other and the actual current which flows, owing to the difference in the two forces is very small. The current flowing as a result of the difference between the impressed and induced electro-motive forces is called the magnetizing current.

From the foregoing it may be seen that the best design of transformer for a given service is one in which the magnetizing current required is very small. A certain amount of iron in the coil is required for given working conditions and if these conditions are varied from, the magnetic flux in the core may be so great as to cause heating or loud humming. When such conditions obtain, the magnetizing current will be very large and the impressed electro-motive force will differ to a great extent from the induced electro-motive force, both in magnitude and phase relation. Transformers are designed for one voltage and if this is varied from, poor regulation or voltage ratio and heating may result. If, for instance, we place a transformer designed for 100 volts on a 500-volt circuit, the magnetization of the coil would be so great that in all probability the transformer would heat badly and hum loudly when carrying its rated load.

To illustrate the law of turns and voltages as applied to transformers, let Fig. 1 represent diagrammatically a transformer consisting of an iron core A and primary and secondary coils B and C respectively. If primary coil A has 10 turns and an electro-motive force of 10 volts is applied to the coil, an electro-motive force of 10 volts is generated and, since the impressed and induced electro-motive force are practically equal, very little current can flow. Each turn of the coil is capable of producing 1 volt pressure. If secondary coil C, with 5 turns, is now wound on the core A, a voltage of 1 volt would be generated in each turn because it surrounds the same magnetizing flux. Since the coil has 5 turns the total voltage of the coil will be 5 volts. This will make clear the fact that any secondary voltage may be obtained by providing the required number of turns in the secondary coil.

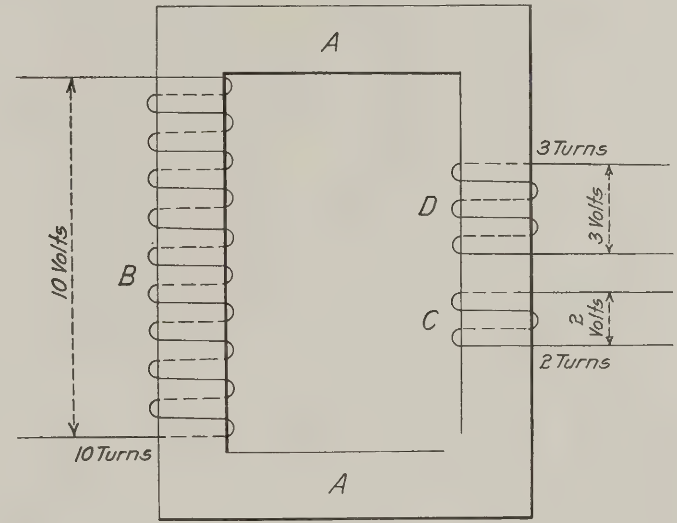


Fig. 2. Diagram of Transformer with One Primary and Two Secondary Coils.

When current is taken from the secondary coil C, having 5 turns, equal to one ampere, it must be noted that this current flowing as a result of the electro-motive force differing in phase from the primary electro-motive force, generates a demagnetizing influence on the core of 5 ampere turns. With 10 turns in the primary coil B one-half ampere will be required in order to produce 5 ampere turns. Thus, in taking 1 ampere at 5 volts from the secondary coil, one-half ampere at 10 volts is absorbed in the primary coil, the same amount of energy. It is very important to note that the ampere turns in the primary coil will exactly balance the ampere turns in the secondary coil and whether the secondary current lags behind or leads its electro-motive force. Thus the insertion of a transformer in a circuit transmits back to the current generating apparatus all the lagging or leading effects due to inductance or capacity in the secondary receiving circuit. The above statements are not entirely exact, as a certain amount of energy is lost in heating the copper in the coils and magnetizing the iron.

As it is sometimes found desirable to obtain more than one voltage from one transformer, Fig. 2 is given to show the arrangement of coils and the results obtained. A represents an iron core, B the primary coil, having 10 turns, on which an electro-motive force of 10 volts is impressed. C and D represent two secondary coils of 2 and 3 turns respectively. A pressure of 2 volts will be obtained from coil C, which has 2 turns, and an electro-motive force of 3 volts from Coil D, which has 3 turns. By connecting the two secondary coils in series an arrangement similar to Fig 1 is obtained with an electro-motive force from the secondary coil of 5 volts. The separation of coils illustrated above may be carried out to any extent desirable; in other words, a transformer may have one primary coil and separate secondary coils for lighting, power or operation of a rotary converter, which is a form of apparatus which will be discussed later.

In following out the action of the transformer it will perhaps be evident that the generation of voltage in the secondary of a transformer is very similar to that occurring in the armature windings of a generator, the difference being that in the generator the voltage is produced by varying the magnetic field passing through the armature coils by rotating them in a constant magnetic field (field coils), while the magnetic field through the secondary coils of a transformer is varied by the varying (alternating) current which passes through the primary coil.

It should be remembered that while the voltage of a transformer varies directly as the number of turns, the current varies inversely as the number of turns so that, neglecting losses in the transformer, the current x voltage in the primary winding always equals the current x voltage in the secondary windings.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 47

Consolidated Type "L" Equipment

In last month's lesson we described the construction and operation of the Consolidated Type "D" generator, and in Lessons Nos. 20 and 31 the system as a whole was described, so in this lesson we will confine ourselves simply to the care and maintenance of the equipment.

Greasing the Ball Bearings

In order to properly clean and regrease the ball bearings of the car-lighting generator, it is necessary to remove both bearings and the armature from the generator, therefore, in describing this process, many other parts of the generator which sometimes require replacement, such as the armature, field coils, etc., will be explained in this connection.

The belt must be first removed and the pulley taken off. This is done by loosening the Columbia lock nut; after this has been loosened about two turns the back or larger nut should be tapped with a hammer to release the lock nut, the whole combination can then be easily unscrewed by hand. The studs of the pulley puller are then screwed into the holes in the pulley hub and the center stud of the puller screwed up tight against the end of the shaft. A few turns of this stud will release the pulley so that it may be removed by hand. Then remove the key from the shaft. It will be noticed that this key is semi-circular in form and can be easily removed by tapping one end, which forces the other end up out of the shaft. The tight fit of the bearing on the shaft makes it necessary to first remove the lock nut at the commutator end of the shaft and withdraw the armature with the pulley end housing complete.

In order to remove the lock nut at the commutator end of the shaft, remove the cover, then remove the cam shaft "G," Fig. 241, with its bearings, cam, and worm gear complete. The split lock nut "J," Fig. 241, should then be removed by first loosening the small locking stud of the nut.

If it is simply desired to remove the armature the bearing closure plate at the commutator end need not be removed, but, inasmuch as in this chapter we are cleaning bearings, we will remove this closure. This, however, requires that the four screws of the pole changer be loosened so that it can be raised in order to permit the bearing closure plate to pass it in removing same from the shaft.

The pulley end housing should then be unscrewed and the housing, together with the armature shaft and the pulley end ball bearing, with housing still mounted on the shaft, removed from the generator, as shown in Fig. 242. By tipping the armature up on end and bumping it on a wood block, the pulley end housing with ball bearing can be removed after having removed the split lock nut at this end of the shaft.

In order to remove the ball bearing from its housing the bearing puller is applied by passing the stud of the puller through the ball bearing and drawing the puller plate up against the inner plate of the ball bearing. The three feet of the bearing puller are placed in the cap screw holes of the housing. A few turns of the puller nut by hand withdraws the bearing from its housing.

After both bearing and grease chamber have been thoroughly cleaned, the bearing should be replaced, regreased and the closure plate applied to prevent dirt getting into the bearing. Be sure that the bearing is started straight into its housing and then driven home by tapping with the *handle* of the hammer at various points around the outer edge; if it is not started straight the bearing will bind.

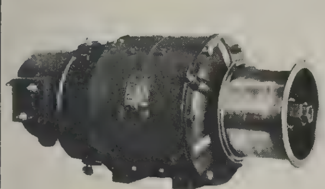


Fig. 240. Small View of Generator, Complete.

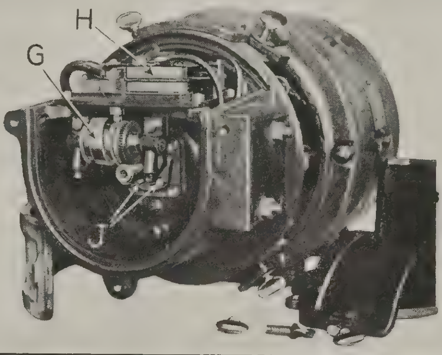


Fig. 241. "G," Pole Changing Cam; "H," Pole Changing Switch, Sideview; "J," Bearing Split Lock Nut.

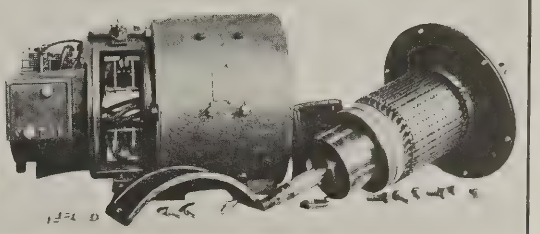


Fig. 242. After Removing the Armature Bump the Shaft Endwise on a Wooden Block to Remove Pulley End Bearing with Housing.

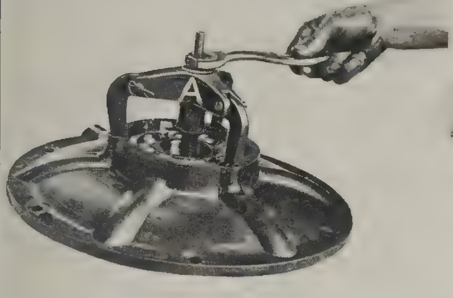


Fig. 243. Place the Three-Legged Bearing Puller "A" in Tap Screw Hole of Bearing Plate Closure.

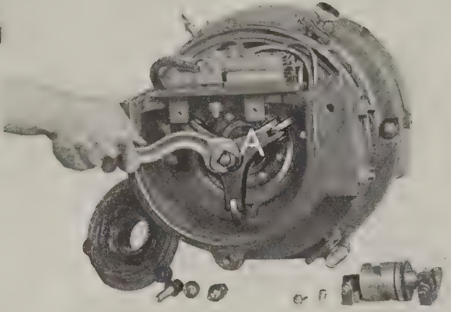


Fig. 244. Method of Removing Commutator and Ball Bearing from Its Housing.

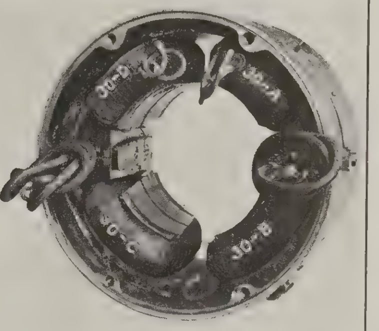


Fig. 245. The Commutator End of the Generator Frame, Showing the Method of Identifying Field Coils. Each Coil is Lettered as Shown.

Cleaning the Ball Bearing

The ball bearing should be cleaned only with kerosene; never use gasolene, as this removes all grease, and this has a tendency to rust the bearing. A convenient way of getting hard grease out of the bearing is to hold the inner race and cause the interrace to revolve by turning an air blast on the balls and outer race, with the bottom part of the bearing revolving in a dish of kerosene. The combination of the kerosene and the air blast will quickly cut out even the most heavy collection of grease.

Do not use live steam for cleaning the bearing, as this takes off every particle of oil and leaves the races and balls dry as a bone. In this condition they will quickly rust, unless thoroughly covered with thin oil before greasing.

Regreasing the Bearing

Use only SF Greoil No. 3 to regrease ball bearings. Each bearing requires only five ounces of grease; never use more than this amount. Wherever a small scale is available the amount of grease should actually be weighed. Should this be impossible, however, proceed as follows: After having replaced the old felt washer of the bearing housing with a new washer, pass the spacing collar, against which the lock nut bears, through the hole of the closure, meanwhile being careful not to tear the felt washer in so doing. Always renew the felt washers whenever cleaning the bearings. Never put back an old washer, as this is liable to allow grease to get into the generator. Then place the closure on top of the tin cover of the grease can with the hollow side of the closure facing upward. Pack the hollow space of the closure around the collar tightly with Greoil until it is flush with the finished top surface of the closure plate. This amount of grease weighs five ounces.

In greasing the commutator-end bearing, pass the short end of the bearing sleeve through the hole of the generator housing, being sure not to tear the felt washer in doing so. With the hands, then apply a thin film of grease to the hole of the sleeve and around the outside of the sleeve where the bearing fits. Also apply a thin film of grease to the hole of the bearing, to the outside of the outer race and to the inside of the housing where the bearing fits. This film of grease is to prevent rusting of the parts after being assembled and thus facilitate taking down the machine the next time work has to be done. It should be noticed that the outer race of the bearing should work around in service so as to prevent one side of the race from receiving all wear as would be the case if the outer race were stationary.

Reassembling the Generator

Both bearings are made to assemble with tight hand forced fits. The commutator end bearing should be inserted in the housing until the outer face of the bearing is at least 1/16 of an inch inside of the finished face of the housing. Then apply the remainder of the weighed or measured amount of grease to the hollow space of the bearing closure plate. Then slip the commutator end collar into place against the housing with the grease pipe at the bottom. Be sure that all surfaces are free from dirt in assembling. Then apply the three spring washers and the three retaining bolts of the bearing closure plate and draw down firmly until properly seated in the housing. Then obtain the proper amount of grease for the pulley end bearing in the same manner as for the commutator end and with clean fingers apply a thin film of grease to the bore of the housing, to the hole in the bearing and to the outside of the outer race of the bearing. A certain amount of grease should also be applied, with clean fingers, to the balls and to the cage.

Next place the bearing in the housing, first starting it straight and tap it gently with the handle of a hammer at various points around the outer race. The bearing closure plate with spacing collar is then mounted on the housing. The three cap screws of the closure plate with their spring washers are then applied to the bearing closure plate. The bearing is now encased in the housing and the housing can then be forced on the armature shaft. In doing this, start the bearing on the shaft straight and then bump the armature shaft on the wooden block. The armature with the pulley end casing complete can then be inserted in the machine. Be careful that the commutator or armature windings are not damaged by striking them against the pole pieces or brush holders.

The armature split lock nut is then applied at the pulley end with the finished face toward the housing. This should be turned to the right until the spacing collar clamps the bearing solid against the shoulder of the armature shaft. The clamping bolt of the lock nut is then tightened with a wrench until the split lock nut is securely locked to the shaft. Be sure that the spring washer is under the head of this bolt.

Then apply a film of grease to the key and also to the keyway, armature shaft, and tapered bore in the pulley hub. Apply the key to its seat in the armature shaft and then place the pulley in position, this being properly lined up with the shaft key and with the large end of the taper bore passing over the shaft first. Press up tightly with hands, and give the pulley a twirl with the hands to see that armature rotates freely. Apply the Columbia lock nut with the hexagon shell toward the pulley. Screw up to pulley hub face by hand, turning to the right, and draw up tight, and give the pulley another twirl to see that armature rotates freely and that the pulley is running true.

The armature shaft lock nut should then be applied at the commutator end of the shaft, turning it to the right until it is drawn up tight against the spacing collar, so as to securely clamp the bearing against the shoulder of the bearing bushing. After the split lock nut is tightened solid the clamping bolt with spring washer under its head should be tightened; this cramps the lock nut, locking it securely to the shaft.

The armature should now have only 1/64 of an inch end thrust. In case there should be more end thrust than this amount, the housing at the pulley end or the bearing closure, either at the pulley end or the commutator end, may not be properly seated; or the bearing lock nuts at each end of the armature shaft do not clamp their respective bearings into position.

The pole changer switch can then be set securely in place and the pole changer switch H, Fig. 241, and the pole changer shaft G, Fig. 241, may then be applied to their original positions. The pole changer cover can then be applied.

Next replace the brushes on the commutator. This should be done carefully, always holding the brush finger away from the brush until the latter is in place on the commutator; then allow the finger to come against the brush easily. A quick snapping and dropping of the brushes into place is very liable to chip or break the face of the carbon brushes. Next apply the front and back brush holder covers and adjust the pulley to proper tension.

Maintenance

Motoring the Generator

The generator should be motored occasionally to prove the armature and field connections. In doing this, remove the belt or loosen it so that the pulley can revolve freely. A motoring switch, located directly below the dash pot of the field regulating solenoid, is applied for this purpose. A cotter pin is passed through the contact in normal running position so as to prevent this switch being closed by unresponsible parties. This cotter pin should be removed when the generator is ready to be motored.

This switch is in parallel with the auto switch, and, when closed, it short-circuits the series winding and the series winding of the regulator solenoid so that the motoring current does not pass through the series coils. This should start the generator revolving at once at a comparatively slow speed, but this speed can be increased by gradually raising the plunger stem of the field regulating solenoid. Be very careful not to touch the rocker contact or in any way break the field circuit at the rocking contact, as this might cause serious arcing or excessive generator speed.

The Generating Test

After the generator has gotten up to high speed, quickly throw the motoring switch to the original position and drop the plunger of the solenoid so that the field circuit will be quickly strengthened. The momentum of the armature revolving at high speed with low resistance in the field circuit causes it to build up its voltage in the same manner as is done on the road. This should be sufficient to close the automatic switch, thus proving that the lifting coils of the switch are operating O. K.

The Railroad Electricians' Club

December Meeting New York Car Lighting Association

Mr. W. L. Bliss, chief engineer of the U. S. Light & Heat Corporation, but better known among his friends as the "silver-tongued orator of the scallywags and villains of the car lighting coach yard," as he put it himself, gave a most interesting address before the December meeting of the New York Car Lighting Club. Mr. Bliss' talk was a more or less general résumé of the whole car lighting situation. He outlined briefly some of the many difficulties experienced by car lighting engineers in the early days when all manner of drives and the various types of generators, regulators, generator suspensions, etc., were being tried out under the tender auspices of the railroad car department.

Mr. Bliss said that one prominent car lighting man on one of the eastern roads stated that he would consider the car lighting problem entirely solved if he could obtain a mileage of 20,000 miles operation without a light failure. In those days, Mr. Bliss said, they were lucky if a car got from Jersey City to the Hackensack River without a light failure.

Accordingly, most of the attention of the car lighting men in the early days was directed toward simply "making the thing go" and providing light for the car, and no thought whatsoever was given to the storage battery as to whether or not it was being overcharged. The chief trouble was to give it enough charge, for with the belt off, or the generator out of commission, about half of the time, this became a problem of sizeable proportion.

Battery Important Part of the Equipment.

Mr. Bliss pointed out that the storage battery is absolutely essential to the operation of any car lighting system, for it furnishes not only a source of power for the lights, when the car is at rest, but it is the foundation upon which all regulators operate. He stated that a car lighting system without a storage battery was, to his mind, a practical impossibility.

Control of Charge.

Mr. Bliss pointed out that, although in the early days the chief problem was to keep the machine going and furnish light, the gradual improvement in construction and operation of the car lighting equipment has made it possible to consider refinements not even thought of in the earlier days. Chief among these are the lamp regulator and the ampere-hour meter control.

Mr. Bliss stated that any stop charging device to be successful must depend on some property of the battery, but at the same time this device must take care of the battery regardless of battery condition, qualities or characteristics. He pointed out that there are numerous readings or indications of the battery condition which might be employed for automatically controlling the charge of a car lighting battery. The battery voltage might be used, the specific gravity indications, the ampere-hour meter charge and discharge record, or even the rise in battery temperature, or the gassing effect at the end of charge might be employed. Of all these, however, the ampere-hour meter indication seems to be the most reliable and the one best adapted to automatically controlling the charge given a car lighting battery. The indications of battery voltage at the end of charge and even the specific gravity are very greatly affected by temperature. In fact, either of these readings means absolutely nothing unless the temperature as well as other operation conditions be known.

The ampere-hour meter, on the other hand, is like a family doctor prescribing a certain diet for a patient. He tells him just how much he can eat, drink, etc.—maybe he comes pretty close to what the fellow ought to have, but when the boss surgeon of the hospital (Mr. Chief Electrician) comes around at the end of the month, he may feel that Mr. Patient (the battery) isn't getting quite as much medicine (current) as he ought, so he gives Mr. Family Doctor (the ampere-hour meter) specific instructions as to future treatment—(by raising the percentage of overcharge given the battery by the meter.

The Lamp Regulator.

Mr. Bliss called attention to the difficulties to be overcome in trying to meet certain specifications for car lighting lamp voltage regulators, and especially emphasized the fact that where as close regulation as within one volt of normal is required the difficulties encountered in designing and building a lamp regulator to meet such requirements are extremely exacting. He called attention to the small amount of power available for operating the lamp regulator. He stated that it was extremely desirable to keep the consumption of current by the lamp regulator solenoid as low as possible and that a current of one ampere through the operating solenoid was about all the up-to-date railroad electrician cared to tolerate. With one ampere flowing through the solenoid of the lamp regulator a change in lamp voltage of one volt means that but one watt power is available for operating the mechanism of the lamp regulator. It certainly takes power to operate a lamp regulator in changing the resistance in the lamp circuit, and this power, moreover, must come from the variation in the lamp voltage itself, hence there must be a variation in lamp voltage in order to produce the necessary changes in lamp resistance to effect the control of the voltage.

He pointed out, moreover, that having two batteries on a car does not eliminate the question of a lamp regulator. It may eliminate an actual lamp regulator, but it introduces the complication of a second battery and its switching mechanism, and two batteries of, say, 150 ampere capacity, cannot be purchased for as low a price as a single battery of 300 ampere-hours capacity.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Emergency Brakes on the Canadian Pacific Bascule Bridge, Sault Ste. Marie, Mich.

The double-leaf Strauss Trunnion bascule bridge built by the Pennsylvania Steel Company, for the Canadian Pacific Railway Company, at Sault Ste. Marie, Mich., has been described so often and so comprehensively by several writers in the various technical papers that no additional description is necessary. Articles describing special features of this bridge appeared in the May and August, 1915, issues of the *Railway Electrical Engineer* under *Practical Stunts.* It may be of interest, however, to review the main features of the bridge, and to describe the trouble which was experienced with the emergency brakes when the bridge was first placed in service.

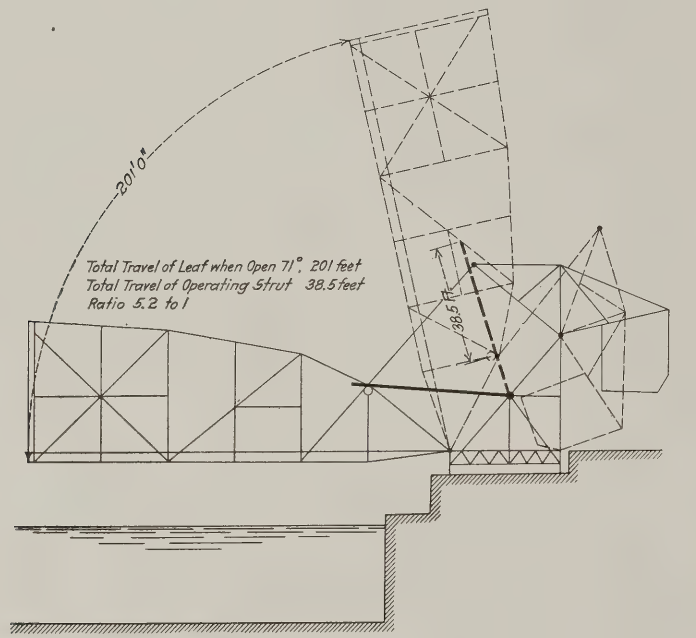

201'0"
Total Travel of Leaf when Open 71°. 201 feet
Total Travel of Operating Strut 38.5 feet
Ratio 5.2 to 1
38.5 ft.

Fig. 1. Showing Relation Between Travel of End of Bridge and Brake-Switch Operating Pinion.

Both leaves of the bridge are controlled from one central tower on the south pier, and when closed they make a single span. While the chord locks constitute the most distinctive feature, the bridge is important in other respects. In the first place, it is the largest of its type yet built, having a span of 336 ft. between trunnion centers. Second, it is designed to permit both passenger and freight trains to pass over the busiest navigable waterway in North America. And third, the quietness of operation and the low maintenance costs of this type of chord lock are evidences that the design is the result of thorough and careful study and experience. When this bridge was first placed in service its operation was carefully observed and complete records were kept of all operating events in order to discover and correct any minor points which might have been overlooked in the designing office, particularly points in connection with the operation and maintenance. A description of some of the troubles found, and the method used to correct them may be of interest.

Each leaf is provided with a powerful spring brake, with electric solenoid release, for emergency purposes. It was found that these brakes did not act properly due to the incorrect design of the spring, which was a spiral of small diameter wound from ⅜-in. round steel. The spring was so stiff in action that after releasing the brake it failed to come back to its original position. A new spring was made by using the same size steel, but wound larger in diameter.

Another difficulty was experienced with the brake switching gear, which were designed to set the brakes automatically in case of overrun. The builders claimed that the brakes would set automatically when a leaf passed the horizon line, or at any point above the horizon according to where the brake-switch tripping mechanism was set, but when this feature was tested it was found that the bridge overtraveled 41.6 in. due to the long arc drawn by the brake release switch. To make the situation much clearer refer to Fig. 1, which shows that the leaf travels 201 ft. from full open to closed position, and that the operating truss on which a pin is mounted to engage the limit switch hand during this movement of the leaf, travels 38.5 ft. The ratio between the travel of the end of the bridge and the pin is then 5.225 to 1. Referring to Fig. 2, it will be noted that the limit switch hand is 12 in. long, and the switch contacts are 6 in. long, which makes a ratio of 2 to 1. Now if it is de-

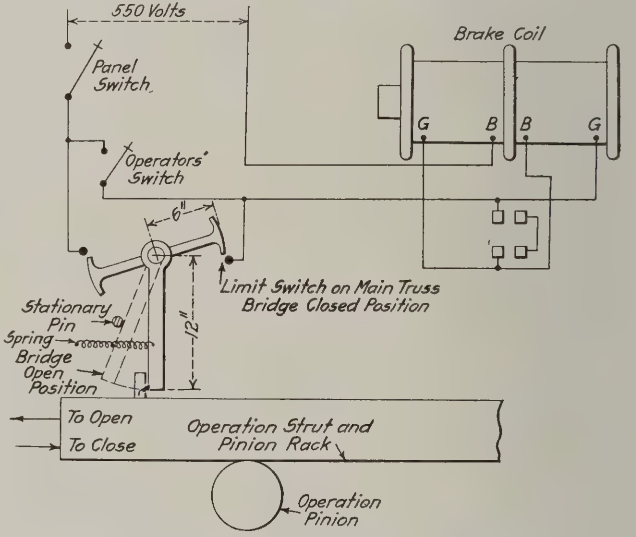


Fig. 2. Details of Operation and Electrical Connections of Limit Switch and Brake Release Coil.

sired to set the emergency brake, this limit switch hand must be moved eight inches by the bridge motion to make the four-inch opening at the contacts required to open the arc. The end of the leaf, therefore, must go 41.8 in. below the horizon line before the brake will act, not counting any lost motion, which is always present.

Referring back to Fig. 2, it is observed that the motion of the switch is very slow, and that the entire working current of the solenoid passes through it. Considering the fact that the solenoid current is 5 amperes, and that the voltage is 550 it is easily understood why it was possible to pull an arc of 4 in. before the circuit was broken. The arc not only delayed the opening of the switch, but also caused excessive burning and annealing of the contacts, which greatly lessened their life.

This difficulty was solved by having the 550-volt switch circuit operate a separate circuit breaker connected in series with the solenoid circuit as shown by Fig. 3. A magnetic switch or circuit breaker C, of small capacity, was installed near the operating panel, one for each leaf, and connected in the brake solenoid circuit behind the panel switch S. The limit switch was taken out of the solenoid circuit and after being slightly altered, as shown on illustration No. 2, was connected in series with the magnetic switch coil CC, which takes a small current. With this arrangement the arc formed is broken when the contacts have opened one-eighth of an inch.

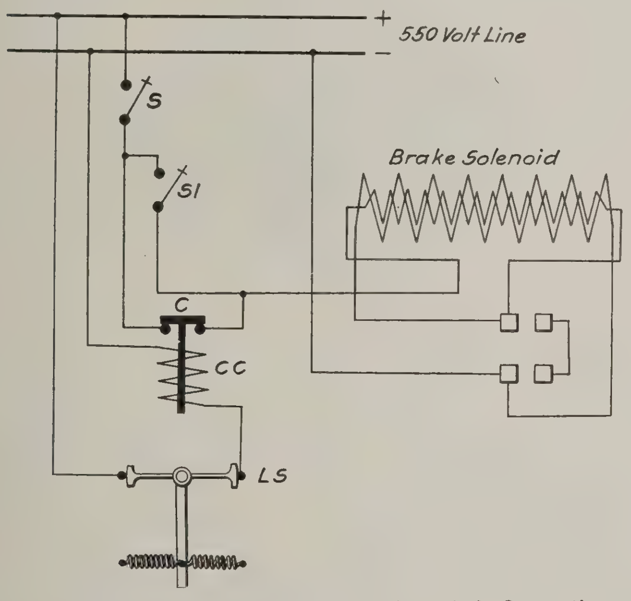


Fig. 3. Showing Changes Made in Limit Switch Connections to Improve the General Operation of the Automatic Brakes.

The switch LS in Fig 3 is shown in the neutral position, at which time the bridge is either being opened or closed. To make the switch more effective pins have been set so as to operate the switch hand on both extreme lower and extreme raise positions of the bridge, so as to prevent overtravel in either direction. The switch LS also continues to serve as a by-pass switch for releasing the brakes before the leaves are operated in either direction.

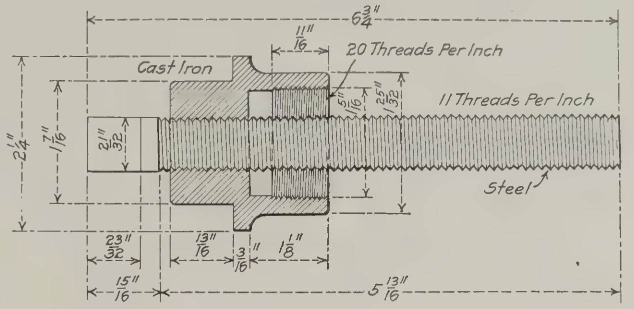
J. G. KOPPEL,
307 South St., Sault Ste. Marie, Mich.

Pyle Armature Puller

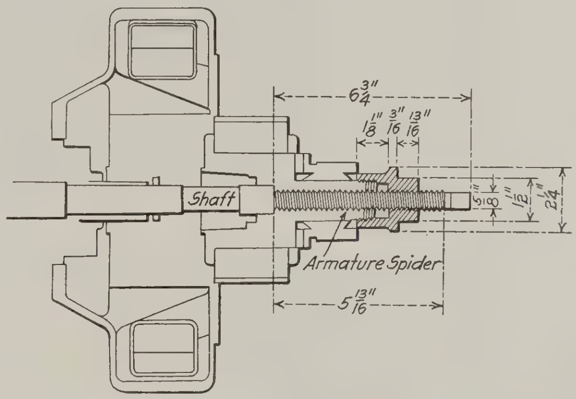
The sketches show the details and application of a device designed by the writer for removing armatures from Pyle Electric Headlight Turbo-Generators.

Although these armatures are intended to be easily removed by hand, we have experienced a great deal of trouble where the shaft was rustd, making it impossible to remove the armature in the usual way or in any other way without damaging the windings.

By using the "puller" an armature can be easily removed without injury to either armature or shaft. The puller illustrated was made from a grease plug and a tap bolt. It is applied to the armature spider by removing the commutator lock nut and screwing the cast iron cap on the threads thus exposed.



Details of Armature Puller.



The Armature Puller In Use. Showing Armature Partly Removed From Shaft.

S. B. COLLINS,
Electrician, Central Vermont Ry.,
St. Albans, Vt.

Chicago & North Western Railway Alters Electric Sign in Chicago.

The display lines on the large Chicago & North Western Railway electric sign situated on the north bank of the Chicago river just west of the Rush street bridge in Chicago have recently been changed.

The old reading matter pertaining to the California Expositions has been supplanted with a strong advertisement of three of the Chicago & North Western Line's principal high class trains—THE NORTHWESTERN LIMITED—THE DULUTH-SUPERIOR LIMITED—and THE OVERLAND LIMITED.

The letters in the names of the trains are five feet six inches in height; the capital letters, however, are higher.

Personal Mention

Paul M. Lincoln

Paul M. Lincoln, for over 23 years connected with the operating and engineering activities of the Westinghouse companies, will on January 1 became associated with the sales department of the Westinghouse Electric & Manufacturing Company, with the title of commercial engineer. Mr. Lincoln, shortly after his graduation from Ohio State University in 1892, entered the employ of the Short Electric Company in Cleveland. He then went to the Westinghouse Electric & Manufacturing Company, and was engaged in the testing-room, and in general engineering work. When the plant of the Niagara Falls Power Company was opened he became its electrical superintendent, and as such had much to do with the first transmission line to Buffalo. In 1902 he returned to the Westinghouse Company, specializing on the general engineering of power stations and transmission lines. He was for several years in charge of the power engineering department, but was transferred to the engineering department when that was organized. Mr. Lincoln is well known in engineering circles through his active work in the American Institute of Electrical Engineers, of which at one time he was president. He is a well-known writer on technical subjects and has also been identified with educational work for some time, filling the chair of professor of electrical engineering at the University of Pittsburgh.

Paul M. Lincoln.

WITH THE S. K. F. BALL-BEARING COMPANY

Mr. H. E. Walker, who has been connected with the S. K. F. Ball-Bearing Company for the past several years in capacity of New York representative, has severed his connection with that company.

W. L. Conwell

W. L. Conwell, vice-president and treasurer of the Transportation Utilities Company, New York, has been appointed assistant to the president of the Safety Car Heating & Lighting Company, effective January 1. Mr. Conwell has been in the service of the Transportation Utilities Company since 1911. He was born at Covington, Ky., January 25, 1887. He received his education in the public schools of Philadelphia and at the University of Pennsylvania, from which he graduated in 1898, with the degree of electrical engineer. He then passed the examinations for first assistant engineer for the United States Navy, but received no appointment because of the cessation of hostilities. He was employed in contracting work as a time-keeper for the Tennis Construction Company, Philadelphia, becoming later chief engineer and secretary of the company. In 1901 he resigned to become city salesman of the Westinghouse Electric & Manufacturing Company in New York. He was later placed in charge of the isolated plant department of the company, and for five years, ending in 1911, was engaged in railway work. In that year he became vice-president of the Transportation Utilities Company.

W. L. Conwell.

William Chaflin Andrews

William Chaflin Andrews, advertising manager of the Edison Storage Battery Company, Orange, N. J., died in New York City, on December 21st. A graduate of Columbia University, Mr. Andrews afterward became sales engineer of the Stanley Instrument Company of Great Barrington, Mass., and later became connected with the General Electric Company in Schenectady, N. Y., and Harrison, N. J. He was for two years secretary of the Rae Company, New York City, leaving to join the Edison Storage Battery Company, in April, 1913, where he was advertising manager until his death. Mr. Andrews enjoyed an unusually large acquaintance among electrical men, and was particularly active in the Electric Vehicle Association of America and in the Jovian League.

W. E. Ballantine

The sad news of the death of W. E. Ballantine, manager of railway sales of the Willard Storage Battery Company, was received just as this issue went to press. Mr. Ballantine has a very wide acquaintance among car-lighting men, and has spent practically his whole life in railroad service. In 1900 he was appointed assistant electrical engineer of Pullman Car Works at Pullman, Ill., and in 1903 was appointed electrical engineer of that company in charge of the electric light plant, shop wiring, manufacture of storage batteries, electric manufacturing department and the equipping of all cars with electricity. In 1905 he was appointed chief electrician of the Rock Island Lines in charge of all car-lighting and electric headlight equipment. In 1909 he was appointed Western manager of railway sales of the Willard Storage Battery Company, and in 1913 became manager of railway sales of this company, with headquarters at Cleveland.

Mr. Ballantine died on January 11 of acute pneumonia. We extend the deepest sympathy of Mr. Ballantine's many car-lighting friends to Mrs. Ballantine in her great bereavement.

William Andrew Conner

William Andrew Conner, of Plainfield, N. J., died suddenly, Monday, December 6th, at his office in Perth Amboy, N. J. He was born in Baltimore, September 12, 1859 and began his business career in 1876, in Pittsburgh, in the oil refining business, in which he reached the position of assistant manager for the Standard Oil Company. In 1885 he took charge of the first plant built by the Standard Underground Cable Company, in Pittsburgh, and from then to the time of his death he was the head of the manufacturing business of that company, including large plants planned and built by him in Pittsburgh, Pa.; Perth Amboy, N. J.; Oakland, Cal.; and Hamilton, Canada. He was a director for 10 years and first vice-president since 1909.

General News Section

Holophane Announcement

Elsewhere in this issue will be noted the announcement of the change of name of Holophane Works of General Electric Company, to that of Ivanhoe-Regent Works of General Electric Company.

The General Electric Company will continue to manufacture and sell Regent glass and Ivanhoe metal reflectors; and although its right to handle Holophane prismatic is no longer an exclusive one, it will continue to furnish this line also.

In its organization the Ivanhoe-Regent Works of General Electric Company is in every respect the same as that hitherto known by the name of Holophane Works of General Electric Company. The company will maintain, as before, a special department devoted to the interests of railway illumination. And this department will continue to keep in touch with the most up-to-date requirements of the railway industry, in order that its service may be as efficient and helpful as possible.

Mr. L. C. Doane, in his capacity of commercial engineer, will continue to represent the organization in the railway department. Mr. Doane has a wide acquaintance among railway electrical men and has taken an active part in the development of modern electric lighting apparatus and systems for special railroad service.

Holophane Glass Company

The Holophane Glass Company, original owners of patent rights for Holophane prismatic glass, announce that beginning with January 1, 1916, they will resume control of the manufacture and sales of Holophane glassware. This company has its headquarters at 340 Madison avenue, New York, and Charles Frank is the sales manager.

A Communication

To the Editor:—

Reading through your November issue of your valuable paper I notice that you quote me, on page 166, as saying that "car lighting in the United States was far superior than in any other country," and I hasten to point out that the meaning of my remarks on car lighting in America is misrepresented by the above statement.

What I wanted to convey is that a great deal of credit is due to the man responsible for the present conditions of electric car lighting in this country, and the fact that light failures are seldom heard of speaks well for maintenance men and equipment, bearing in mind the mechanical and electrical stresses imposed by the type of machines generally used in this country. Car lighting, however, from a point of simplicity, reliability and efficiency cannot be called superior to that of any of the foreign countries I mentioned in my talk. Furthermore, I feel sure that the *Railway Electrical Engineer,* the only paper of its kind in the world, is largely responsible for the wonderful co-operation and exchange of ideas among the various maintenance men, and it seems to me that not a small amount of credit is due to this paper for the present state of car lighting in this country. In the few foreign places where this paper has appeared it has always been greatly admired.

Trusting that you will insert these lines in your next issue in order to clear this matter up with your readers, I am,

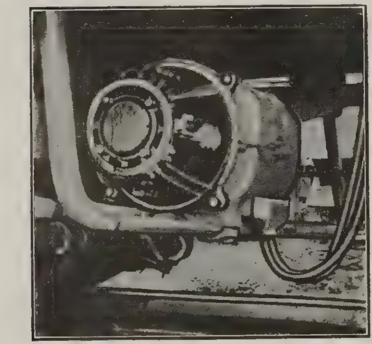
Very truly yours,
H. D. ROHMAN,
Chief Electrical Engineer,
Franklin Railway Supply Company.

E. S. B. Announcement.

The Electric Storage Battery Company, of Philadelphia, announces a change in the handling of its Pacific Coast business to take effect January 1, 1916.

Due to changes in the organization of Messrs. Pierson, Roeding & Co., who have acted as The Electric Storage Battery Company's sales agents on the coast since 1910, the battery company will hereafter conduct its business on the coast through Mr. George R. Murphy, soliciting agent, with offices in the Rialto Building, 118 New Montgomery street, San Francisco.

Through the Galveston Flood.



Car lighting generator which was submerged 14 hours in Galveston flood without harmful results.

Many of our car lighting generators passed through the recent Galveston flood and were submerged in salt water for 14 hours. It will be interesting to learn that many of these generators upon being removed and opened for inspection showed the generator in perfect condition. The accompanying illustration shows an E. S. B. generator which passed through the flood, was submerged 14 hours, and upon being opened the interior was found to be perfectly dry and the generator free from grounds or armature or field shorts.

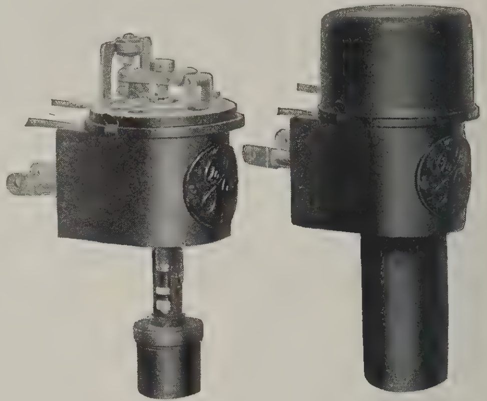
Aleck Voight,
Assistant Electrical Engineer, Santa Fe.

New Compensator Type Relay.

A new type of circuit-opening inverse time limit oil dashpot relay has recently been developed by the General Electric Company for use in conjunction with a low voltage release for automatic, overload and low-voltage protection of alternating current motors up to 2,500 volts and 300 amperes.

The relay is connected in series with the line, the low voltage release across one phase in the usual manner with the low voltage coil in series with the relay contacts.

On overload greater than the current setting of the relay, the relay contacts open-circuit the low voltage release coil and the motor is cut out of circuit.



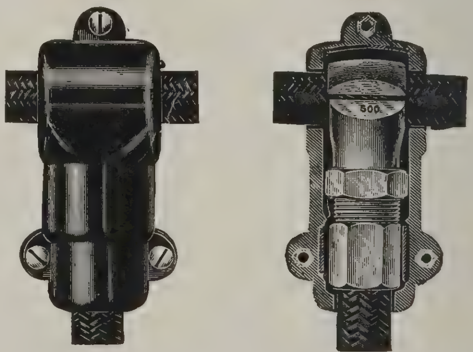
New Compensation Type Relay with Cover Removed.

If the voltage drops to a predetermined per cent of normal, the motor is also disconnected from the power supply. Here series relays replace the secondary relays, current transformers and oil switch tripping coils otherwise required.

Current calibration is from normal to twice normal, and time adjustment from 10 sec. to 5 min. on 25 per cent overload. The delay recommended, however, is about 15 sec. at the starting current of the motor. This affords ample protection to the motor against damage from overload or single-phase operation, but prevents the circuit from being opened while the motor is starting.

New Insulating Cover for Dossert Cable Taps.

The illustrations show a new type of insulating cover for branch connections when made with Dossert Cable Taps. As shown the covers are in two parts, which, when joined together, are held by machine screws, nuts being imbedded in the insulating material. The facility with which both connector and cover can be connected or disconnected is noteworthy. These devices are being largely installed on switchboard wiring in power and substations and in shop wiring at points where taps for motors are taken off the main feeders, and on switchboards where taps are taken off bus bars. The insulation possesses good mechanical strength and will not expand, contract or deteriorate in service. Tests have established its efficiency up to a maximum of 28,000 volts. These connectors and insulating covers can be supplied for various sizes up to 500,000 C. M. They are manufactured by Dossert & Co., 242 West 41st Street, New York.



Application of Insulating Cover for Dossert Cable Taps.

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Results of the Norfolk & Western Electrification

On another page of this issue appears an article describing some operating and maintenance features of the Norfolk & Western electrification.

Information available at this time indicates that, after eight months of electric operation, the capacity of the entire electrified section has been practically doubled, due to the increase in both train speed and train tonnage. The single-track Elkhorn tunnel with its steep grade was formerly the most serious cause of congestion. With steam operation it was not uncommon for a tonnage train to require from 30 to 40 minutes to go through, at an average speed of about six miles per hour, while with electric operation the tunnel is traversed in about two and one-half minutes at a speed of 14 miles per hour.

It is also interesting to compare the facilities required by steam and electric locomotives. Where formerly rather extensive roundhouses, coal and water stations, cinder pits, turntables and repair shops were required, the entire terminal and shopping facilities for the electric locomotives consist of one inspection and machine shop for general overhauling, and one outdoor pit, a small frame office building and few sand boxes for terminal inspection and repairs; no roundhouses, turntables, etc., being required.

The three-phase motors which are used have shown up well and in fact this type of motor seems to be especially adaptable to the conditions met with on the Norfolk & Western. The three-phase motor permits the transmission of large blocks of power at a high single-phase voltage, it provides reliable and effective electric braking and regeneration of power on the heavy down grades, it delivers extremely high starting torque and, due to its inherent characteristics, stands up under a great deal of abuse.

The electric braking of heavy tonnage trains on steep grades has proved to be one of the most satisfactory results of this electrification. It is difficult to imagine a 3,250-ton train going over a 25-mile section of a typical mountain railroad division at a constant and rather monotonous speed of 14 miles per hour without a single application of the air brakes except when coming to a dead stop. That, however, is an everyday occurrence on this road and to a layman the sight is most impressive.

This electrification has also demonstrated the practicability and durability of the light, flexible overhead type of catenary construction for supplying power to high-power locomotives.

Another interesting development of this electrification is that all ordinary line repairs are made by a crew of five men traveling on a small standard gasoline car, which hauls a small tower car. A "hot-ladder" of treated wood is also carried, which the men lean against the live trolley and catenary wires and from which they make any necessary repairs to these wires while they are "hot."

Anti-Friction Bearings for Shop Motors

The installation of anti-friction bearings in axle generators, car fans and headlight turbines has proved to be such a marked success that we believe the application of roller or ball bearings to shop motors would also prove to be desirable and advantageous. The induction motor, which is used more than any other type for shop purposes, has, in its small air-gap an inherent weakness which when the ordinary sleeve and ring-oiled bearings are used prevents it from being a fool-proof machine. With the regular ring-oiled sleeve bearings this type of motor may run for months at a time exposed to sawdust, shavings, lime dust, coal dust, etc., without causing a fire and without any wear except at the bearings, because of the absence of a commutator and of other moving contacts, but unless carefully and periodically watched, and lubricated with the proper oil there is danger of the bearings wearing down to such an extent that the rotor will rub against the laminations of the stator, in which case serious trouble will result.

For this reason it seems desirable to equip induction motors with anti-friction bearings and it is reasonable to expect that the results will be as satisfactory as they have been in the case of similar improvements in axle generators, fans and headlight turbines. In addition to minimizing the trouble resulting from the small air-gap there would be the additional advantage of decreasing the number of inspections required per year. This latter feature is of especial importance where the motors are located in places which are hard to reach, such as on the wall or on the roof truss, or on the top of a machine tool frame and other places where the motor is out of sight or difficult to reach and therefore liable to be forgotten or purposely avoided. Another source of trouble with ring-oiled bearings which could be eliminated by the use of anti-friction bearings, is that very often men who have charge of these motors, due to the lack of experience or perhaps because they cannot get the proper oil, sometimes use oil that is so heavy that it prevents the ring from turning. In any event the subject of applying anti-friction bearings to shop motors is one worthy of thoughtful consideration on the part of railroad electrical men who are interested in reducing the maintenance costs of their shop motors to a minimum and of increasing their reliability.

Illumination and Accident Prevention

In a paper presented at the ninth annual convention of the Illuminating Engineering Society, Washington, D. C., September 20 to 23, 1915, R. E. Simpson presents the results of one year's study of industrial accident records obtained from workmen's compensation and accident insurance companies' reports. The object of this study was to determine what percentage of the total number of accidents were caused, either directly or indirectly, by the lack of proper illumination. Mr. Simpson shows that out of 91,000 accidents, which occurred in and about industrial plants, 23.8 per cent were due directly or indirectly to improper illumination, that 10 per cent were due primarily to inadequate illumination and in the remaining 13.8 per cent the lack of proper lighting facilities was a contributary cause.

The logical conclusions to be drawn from this paper are that lighting units must be properly spaced, must be mounted at a sufficient height and proper reflectors must be used and carefully maintained, especially with high efficiency lamps, if the number of accidents are to be reduced to a minimum, and this is what we are all intensely interested in doing.

Incandescent Headlights and Headlight Laws

There is little doubt in the minds of the majority of railroad officers that the incandescent electric headlight is far superior in every way to the arc headlight, but in many cases they are a little dubious about adopting the former type in the face of the chaotic condition of the various state headlight laws, which in most cases specify that a headlight shall be used with a light source having an intensity of not less than 1,500 candlepower, measured without the aid of a reflector. Under such conditions they feel that the only headlight which will meet these requirements is one having an electric arc for a light source. In this connection it is interesting to note that the master mechanics' test at Columbus brought out the fact that none of the arc lights, which were tested, showed an unaided candle power of over 1,000. The strongest arc gave about 894 candlepower without a reflector. Taking a specific case, arc lamp headlight number 19 with an apparent beam candle power of between 55,000 and 60,000 had a lamp which gave 941.88 candle power without the aid of a reflector, whereas incandescent lamp headlight number 13½ required only a 90.2 candle power lamp to give 55,000 apparent beam candle power; it seems, therefore, that there is not one arc lamp used in headlight service today that will meet the 1,500 candle power requirement of several of the state laws. Another fact brought out in the report of this test, which shows that the arc headlight is unsuitable for railroad service, was that a headlight with a beam candle power of over 50,000 develops about 30 per cent phantom lights.

Another serious inherent fault of the arc lamp, when used as a headlight, is that its light is extremely rich in blue rays and consequently this type of lamp produces a large amount of light which is of no value whatever in enabling the engineman to identify an object on the track. For this reason a tungsten filament incandescent lamp, which gives a white light, is from eight to ten times as efficient as an arc lamp as regards the distance at which a certain object can be picked up on the track by the headlight.

If the motive behind the legislation in the different states affecting the headlights were to be analyzed it would be found without a doubt that the object was not so much to secure a headlight with a high candle power source as to secure a headlight which was better and more reliable and satisfactory than those which were in general use at that time. It was simply a case of using an unfortunate definition, not realizing that the candle power of the lamp used in a headlight plays very little part in the final results, the size and shape of the reflector and of the light source, the condition of the reflecting surface and the quality of the light being, in many cases, more important than the candle power of the lamp itself.

Considering the fact that the arc headlight not only does not meet the requirements of the 1,500 candle power laws, but in addition is objectionable and dangerous because of the blinding and phantom light effect of its high intensity, unsteady and concentrated beam and because of its high maintenance cost and its unreliability due to the complicated arc lamp mechanism, it seems that its continued use in locomotive headlights is unwarranted when a much more satisfactory substitute is at hand.

Incandescent headlights of various makes and voltages are on the market and both the 6-volt and 32-volt sizes have proved reliable and efficient from all viewpoints, including those of track illumination and energy consumption.

Philadelphia-Paoli Electrification of the Pennsylvania

Additional Notes on Construction Methods Employed*

The electrification of the Pennsylvania's suburban service between Philadelphia and Paoli, was fully described in our December, 1915, issue. However, the additional information given in this article on the construction methods employed will be of interest.

As the electrification covers one of the busiest and most important main line sections of the railroad and includes the equipment of a large and congested terminal, the methods employed to insure prompt and safe conduction of the erection work will be of interest. All designing and all construction, except the purchase of electric apparatus and the erection of the substation buildings which were contracted for, was carried out by the regular departments and the special forces of the railroad company.

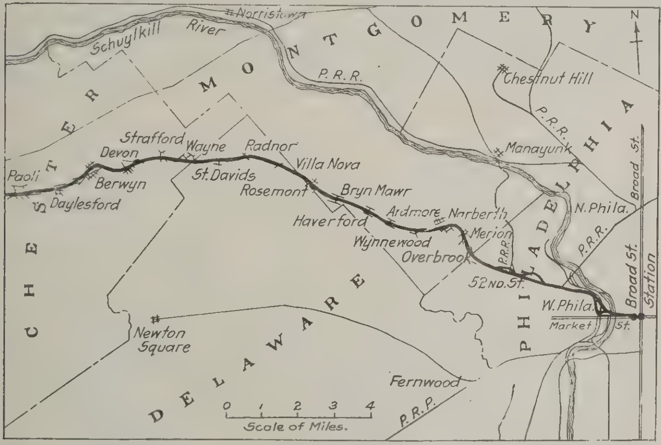


Fig. 1. Map Showing Electrified Portion of the Pennsylvania Between Philadelphia and Paoli.

Designing.—The first important operations were in the designing offices, where the plans for all structures were made in detail. The field forces were supplied with exact information for all foundations, which was the first field operation undertaken. It was especially important to avoid, as far as possible, all cutting and fitting of wires, hangers, etc., in the field; hence, elaborate and complete plans were made in the designing room to determine the position which the trolley wire would assume at each and every point over the line with certain predetermined sags, the location of messenger in reference to the tracks, etc. The calculations established, the lengths of all trolley wire hangers, which were from these plans furnished to the field cut to length and fitted with their attachments. When put into position, it was found that the trolley hung in its proper plane and position with but little field adjustment. While this process involved a large amount of designing, it is felt that it was amply justified by the resulting saving in cost and time during the construction period.

The main elements in the construction work were disposed of as follows:

Foundations.—Excavations for about 412 bridge foundations were required. The soil was for the most part of clay, which was stiff enough to require no shoring when the excavation was followed closely by the concreting. Some rock, however, was encountered in portions of the line, and where found, was cut out by air hammers, as the work was so close to the tracks that blasting was considered dangerous.

Concreting.—The aggregates for foundation concrete were distributed by a work train in approximately the required quantities adjacent to each foundation. All concrete was hand-mixed on boards, in the proportion of 1—2.5—5, and was poured very wet so that it was not necessary to do a great deal of tamping.

The tubular pole foundations, which are rectangular in cross-section and of varying dimensions, were provided with vertical rods and reinforcing hoops of ½ in. twisted rods for shear. These foundations required no foundation bolts, the pole being set in a center hole formed by a collapsible core. In general, the foundations required no forms except just below and above the ground, as the clay was stiff enough to properly stand up until the concrete was poured.

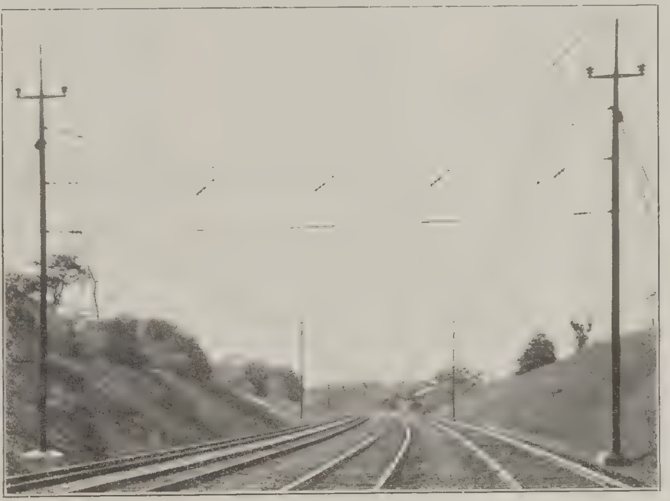


Fig. 2. Catenary Construction Over Curved Track.

As far as practicable, the excavation for the ground end of the anchors was made at the same time as that for the pole foundations, and the concrete slab at the bottom of the anchor poured at the same time as the main foundation.

Catenary Supports.—The foundations were practically all completed before the erection of bridge structures began. The poles were unloaded near their respective locations, and while lying on the ground were fitted with attachments, such as crossarms, castings, etc. The poles were then lifted into place in their foundations by using a derrick car. They were afterwards lined-up and shimmed in place by wooden wedges which held them until the work train followed and grouted them permanently in place. The anchor and signal bridges were erected into position by a derrick car from the freight car on which they were received.

---

* Abstract from a paper presented by Mr. Geo. Gibbs before a joint meeting of the Philadelphia branch of the A. S. C. E. and Engineers' Club of Philadelphia, on Monday, January 3. Mr. Gibbs is consulting engineer for the Pennsylvania Railroad.

Cross Spans.—The next operation was to erect the cross-catenary between the side poles. This structure consisted of top and bottom wires with their connecting links all previously fitted together at the construction yard. These pieces were loaded on a work train and hung in place from the train. The whole catenary pole span was then completed by putting on its guy rods after making final adjustments for tension and was then ready for the erection of the longitudinal catenary.

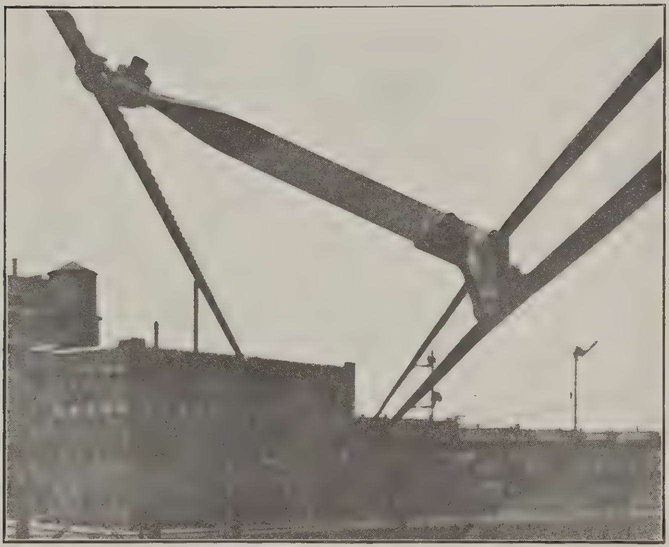


Fig. 3. Wrought Iron Trolley Hanger and Method of Its Attachment to the Catenary and Trolley Wires in Curved Track Construction.

Longitudinal Catenary.—When enough structures and bridges were in place and the insulators suspended from them, wire stringing work trains were organized. These were usually made up of one or two flat cars to carry the reels of wire, one or two tower cars and a box car used as a material and tool car. These trains were, of course, moved by steam locomotives. The steel messenger wire was fed out from the top of the tower car and strung from anchor bridge to anchor bridge and adjusted to the proper unloaded tensions, which were furnished by the office. Until final adjustments were made this messenger wire was supported on pulley blocks suspended from the insulators, thus allowing it free play longitudinally. These blocks were removed later and regular supporting castings substituted.

The cable, while suspending its own weight only, was given such a tension as would be necessary to insure proper sag when fully loaded. This tension was computed and furnished the field by means of the curves showing the relation between temperature and tension for each stretch between anchor bridges. The proper tension was obtained by means of a dynamometer and the cable allowed to stand a while and adjust itself to approximately uniform tension throughout its length and then finally socketed and anchored at both ends.

Following the erection of the messenger wire a train made up of several tower cars would mark the proper location of the hangers on the messenger in accordance with the drawings and fasten in position the hangers which had previously been cut to length and fitted with castings.

The next operation was to string the auxiliary and the main trolley wires from anchor bridge to anchor bridge, holding the wires temporarily at the bottom of the hangers by means of iron straps which could be readily and quickly applied.

The final operation was to adjust, by a train of tower cars, the trolleys to their proper tensions and to clip them in. Where crossovers, sectioin breaks, etc., occurred the fittings were put in as a last operation as they required generally one or two tower cars only to accommodate the workmen who could be employed to advantage in the short lengths involved.

Work Trains.—It will be seen from the above that the composition and proper management of the work train service was very important, in order not to block regular traffic unnecessarily. Practically all work was done by daylight, night work being permitted only for a period of about two months in Broad Street Station in order to clean up certain work which could not be done by day, on account of the traffic. The rapidity of the progress of the work was largely regulated by the amount of time the tracks could be given up for the occupancy of work trains. Generally, on the four-track portion of the main line we were allowed to occupy the inside track of the inbound pair in the mornings, and the inside track of the outbound pair in the afternoons. The stringing of wires over the outside tracks was done from the middle tracks by outriggers on the tower cars. These outriggers were so designed that they could be occupied by the workmen without interfering with the steam traffic underneath on that track.

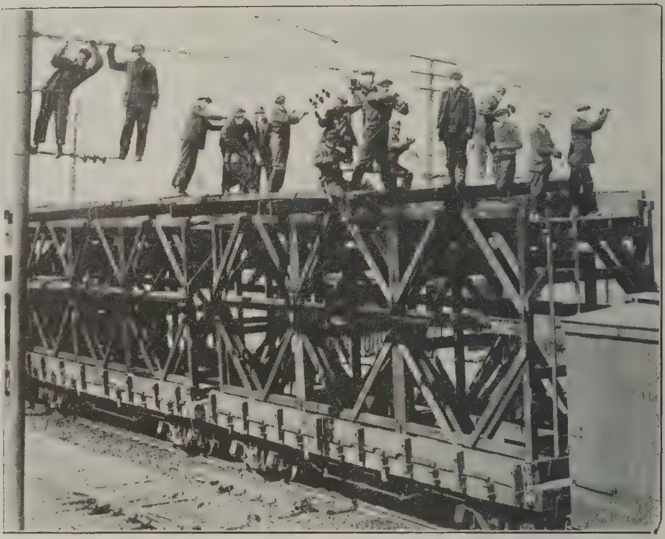


Fig. 4. Special Car for Erecting Catenary Work; Removable Outriggers Make it Possible to Work Adjacent Track Without Interruption to Traffic.

In all ten flat cars were equipped with towers, the working platforms of which could be readily raised and lowered by means of chain blocks. When in the lowered position the towers have a height of 18 ft. 6 in. above the rail with a possible raise of 4 ft.

Men Employed.—The men employed in the construction work varied in number from 200 to 685, and were variously divided into gangs at different stages of the work between laborers on excavation and concrete, iron workers on eretcion of structures, linemen for stringing the wires, bonding gangs on track bonding, carpenters on forms and miscellaneous workmen and wiremen on equipment of substations.

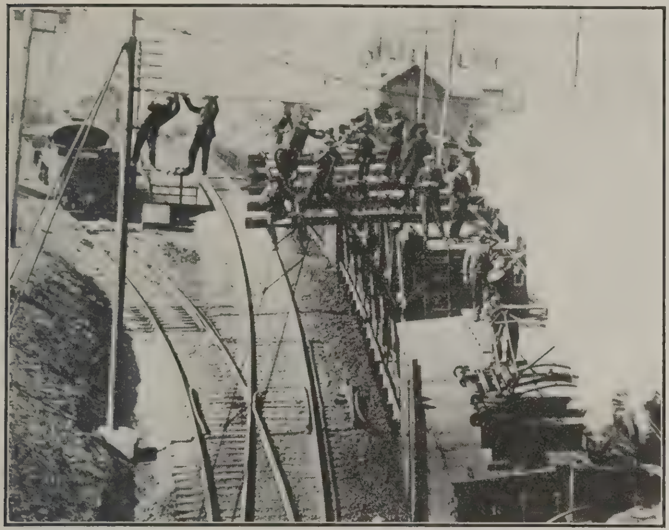


Fig. 5. Another View of the Special Construction Car.

Amount of Work Done.—Foundations for catenary bridges were completed at the average rate of about two per day, reaching six per day at the maximum. With the derrick car twenty-five poles could be picked up and set in place per day. The tubular bridges were erected and completed at the rate of two per day. The erection of longitudinal wiring, including messenger and trolleys, clipping in and adjusting, etc., was completed at the rate of 3.1 track miles per day for straight-away work. The wire train stringing four wires at once could run out eight miles a day. In complicated yard work the progress was, of course, much slower. Thus, at the various interlockings in the Broad Street Terminal, a given section of tracks could not be occupied for any great length of time, so that much time was necessarily lost in waiting and switching in and out of position. In this location, however, the work was extremely complicated and tedious, as there were about 44 crossovers and 50 switches in the portion of the yard electrified. Generally three trains were at work in this section during the day with one train at night. It required the equivalent of one train at work for about twenty-six weeks to string the trolleys and clip them in and to make the section breaks, crossovers, etc., complete. Track bonds were applied at the average rate of about 250 bonds a day.

The Norfolk & Western Electrification

Additional Notes on Operation and Maintenance

A complete description of the construction and equipment of the Norfolk & Western electrification appeared in the June, 1915, issue of the Railway Electrical Engineer, but in view of the many new features involved in this electrification some additional notes on the operation and maintenance will be of interest at this time.

Although fully described in a previous issue a brief outline of the important features of this electrification will not be out of place.

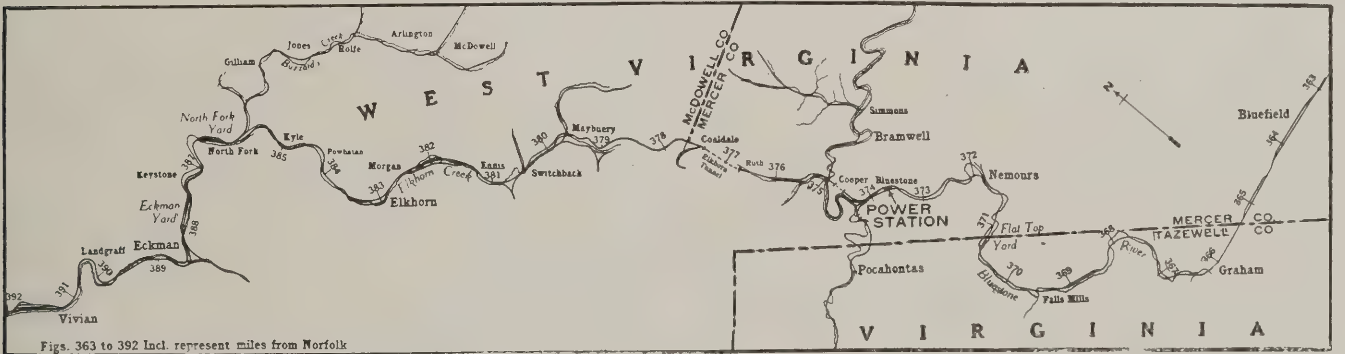


Fig. 1. Map of the Electrified Section of the Norfolk & Western Between Vivian and Bluefield.

Construction and Equipment Details.

The electrified section is located in the southern part of West Virginia in the midst of the Pocahontas Coal District and extends from Bluefield to East Vivian, a distance of about 30 miles. There is a total of about 100 miles of single track in the electrified zone, including the double track main line and the numerous side spurs.

The 3,100-ft. Elkhorn tunnel is the only part of the electrified section not double tracked. The line between Bluefield and East Vivian, which winds around a narrow steep-sided valley, is very crooked, about 60 per cent of the entire division being curved, with a maximum curve on the main line of 12 degrees. The grades are also numerous and heavy, the four-mile approach to the Elkhorn tunnel from the west being 2 per cent and the one-mile approach from the east being 2.36 per cent.

The main traffic, which consists of loaded coal cars, is eastbound. The westbound traffic is for the most part, empties which are distributed to the various mines on the west slope. Considering the roadbed conditions outlined above, together with the fact that the average eastbound traffic, at the present time, is about 35,000 tons per day, with 3,250 tons per train, it is easy to understand why the high voltage outerhead trolley system was chosen. The system finally installed is known as the single-phase, 11,000-volt trolley system, which consists of an 11,000-volt catenary suspended trolley, from which current is collected by a bow-pantagraph on the locomotive. A transformer carried in the locomotive cab transforms the voltage from 11,000 to 750 and a phase converter, operating at the latter voltage, furnishes three-phase current to the wound-rotor induction motors, of which there are eight on each locomotive. The system operates at 25 cycles. The motors are wound for two synchronous speeds, 14 and 28 miles per hour, and are started by inserting water rheostats in series with the rotor windings.

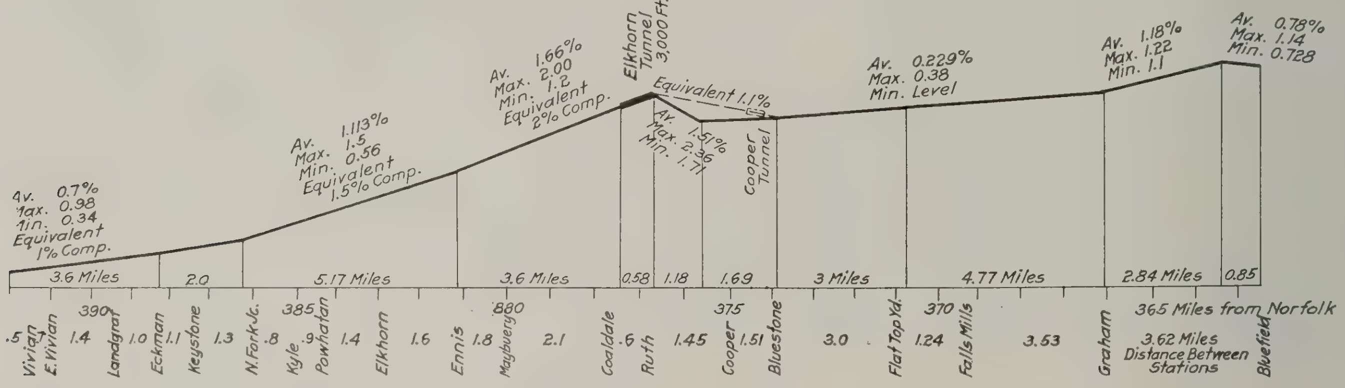


Fig. 2. Diagram of Profile from Vivian to Bluefield.

The 12 double cab, 270-ton locomotives, which are now in services, have developed a much higher draw bar pull than was guaranteed by the builders. The tables show their principal dimensions and performances.

	Ft.	In.
Length overall	105	8
Driving wheel base, total	83	10
Rigid wheel base	11	0
Truck wheel base	16	6
Height, rail to pantagraph (Locked)	16	0
Height, rail to top of cab (Maximum)	14	9
Width overall (Maximum)	11	6¼
Width over cab body	10	3
Diameter of driving wheel		62
Diameter of pony wheels		30
Weight on drivers	220 tons	
Total weight of locomotive	270 tons.	

	Train on 1.5 and 2 per cent grades	Train on 1 per cent grades	Train on 0.4 per cent grades
Weight of trains, tons	3,250	3,250	3,250
Locomotives per train	2	1	1
Approximate speed, miles per hour	14	14	28
Drawbar pull per locomotive, pounds			
Uniform acceleration	91,800	114,000	79,400
At speed on 2 per cent grade	75,400		......
At speed on 1 per cent grade		85,800	
At speed on 4 per cent grade	......	......	4,600
Maximum guaranteed accelerating tractive effort per locomotive	133,000	133,000	90,000
Approximate maximum guaranteed H.P. developed by motors	5,000	5,000	6,700

The traction powerhouse is located in Bluestone, about 14 miles west of Bluefield. Single-phase power is obtained from three-phase turbo-generators, which have a single-phase rating of 10,000 k.w. at 80 per cent power factor. The current, after being stepped up to 44,000 volts, is transmitted to the various substations, where it is again stepped down to the trolley pressure of 11,000 volts.

Operation.

At this time complete data on the economy of the electric operation as compared with previous steam operation is not available, but certain evident advantages of the new system are most interesting. Early in 1914 the average number of trains hauled by steam engines in both directions over the section under consideration was nine, each train weighing about 2,900 tons. This is equivalent to 26,100 tons per 24-hour day. Each train was hauled by from two to three mallet compound locomotives, depending on the grade, and a total of 20 such engines were required for this service.

The use of electric locomotives has had a marked effect on the operation of trains through the Elkhorn tunnel. The dispatcher will now allow a full tonnage train to leave Eckman Yards, eastbound, ten minutes before a local passenger train is due, and will allow the same train to enter the tunnel four or five minutes ahead of a passenger train, as he is perfectly sure that it will come through without delay. Formerly, 20 minutes was the time figured on for a 3-mallet engine train through the tunnel, not only because its speed was less, but also because of frequent stalling. Two electric locomotives consistently pull a 3,250-ton train through the tunnel in about three minutes.

It will be of interest to follow an electric locomotive on one of its regular round trips over the line from Bluefield to East Vivian or Eckman and back. (The main yards at the west end of the line are at Eckman.) Leaving Bluefield inspection track, the locomotive goes to the West Bluefield Yards, picks up a train of from 85 to 95 empties, and proceeding westward, sets them off at the various mines in the coal field west of the tunnel. Proceeding on to Eckman, the locomotive, without turning, picks up what is known as a tonnage train of 3,250 tons, consisting of from 28 to 45 cars, depending on their capacity, and starts east. A pusher is used from Eckman to Ruth (at the eastern portal of the Elkhorn tunnel and at the summit of the 2 per cent grade). The single locomotive then takes the train to Flat Top Yards, where additional tonnage up to 4,750 is accepted. The run from Flat Top to Bluefield is made with the help of a pusher, on the 3-mile

1¼ per cent grade at the end of the division, between Graham and Bluefield.

The round trip from Bluefield to Eckman and back is made in the average time of seven hours and two such trips constitute an average day's work for one train crew. Formerly, with steam operation, a day's work for our train crew consisted of a single round trip between Bluefield and the coal field, which usually took 12 hours. There are usually 9 of the 12 electric locomotives actually on the road, with one at Bluestone undergoing general repairs, one idle at Bluestone for relay and one over the inspection pit at Bluefield.

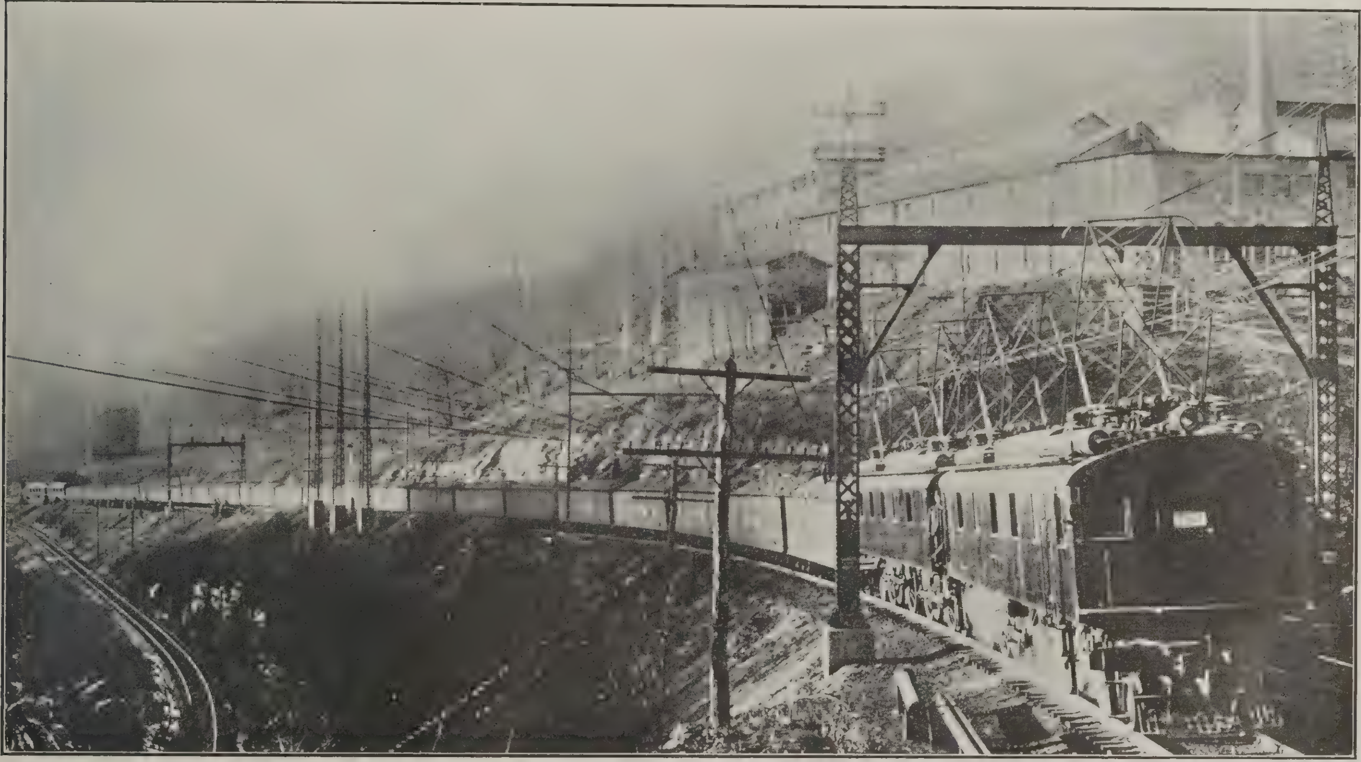


Fig. 3. A Full Tonnage Train Consisting of 25 180,000 lb. Capacity Coal Cars and Two Electric Locomotives.

Some ammeter readings taken on one of these trips may be of interest. These readings were taken from the four ammeters in the cab, each meter registering the current taken by each of the four trucks. Normally the current taken by the different trucks is equal; therefore, the total current taken by the locomotive is four times the reading of one ammeter.

The train (westbound) consisted of one electric locomotive with a trailing load of 92 empties. When going up a 1.4 per cent grade west of Bluestone at 14 m.p.h. the ammeter showed 500 amperes, and when coasting down the 2 per cent grade through and west of the Elkhorn tunnel an average regenerative current of 300 amperes was registered. Later, when coming east with 23 75-ton cars (over half a normal tonnage train) with one locomotive, the ammeter showed 550 amperes on the 2 per cent up grade and a regenerative current of 400 amperes on the 2.36 per cent down grade. One locomotive will take a full tonnage train of 3,250 tons down the 2.36 per cent grade at about 15 m.p.h. without air brakes. Under such conditions, which are normal, the regenerative current per truck is about 550 amperes.

It is a most impressive sight to see one of these heavy coal trains hauled up one side of the mountain and lowered down the opposite side at a constant speed, without the use of air brakes and with no indications of the change in grade other than the gradual fall and rise of the ammeter needles. The regenerative ability of the three-phase motor is one of the main factors which makes their use for this severe service particularly successful. Another characteristic of the three-phase motor which has proved most valuable is its inherent ruggedness, due to the absence of a commutator. When starting a heavy train on a grade with a steam locomotive the pusher does not shut off steam when the head engine stops the train with the air brakes. It simply holds against the train with open throttle and in so doing permits the head engine to release the air and pick up its share of the slack when ready to start. When the front half of the train is under way the "Pusher" will start its half and the entire train will move with a minimum of jarring and bumping. Of course, poor track and weather conditions may complicate matters to such an extent that perhaps three or four minutes might be required to start.

The three-phase motors on the electric locomotives are peculiarly adapted to stand up under the severe conditions above mentioned when starting a heavy train. In fact, their ability to stand still under full load for a maximum of five minutes, while holding a train about to be started on a heavy grade, contributes in a large measure to their success in this installation.

Locomotive Maintenance.

The facilities provided for the inspection and maintenance of the electric locomotives appear ridiculously small when compared with the extensive and elaborate facilities required for the proper maintenance of an equal power in steam locomotives. One rather small machine and inspection shop at Bluestone and one small frame office and store building, and open air inspection pit and six sand boxes, at Bluefield, are all the electric locomotive facilities provided. The absence of roundhouses, coal docks, cinder pits, water tanks and large machine shops is particularly noticeable and impressive. The general inspections and heavier repairs are made in Bluestone, a point about 11.5 miles west of Bluefield, while the terminal inspections and light running repairs are made at Bluefield, the eastern terminus of the electric zone.

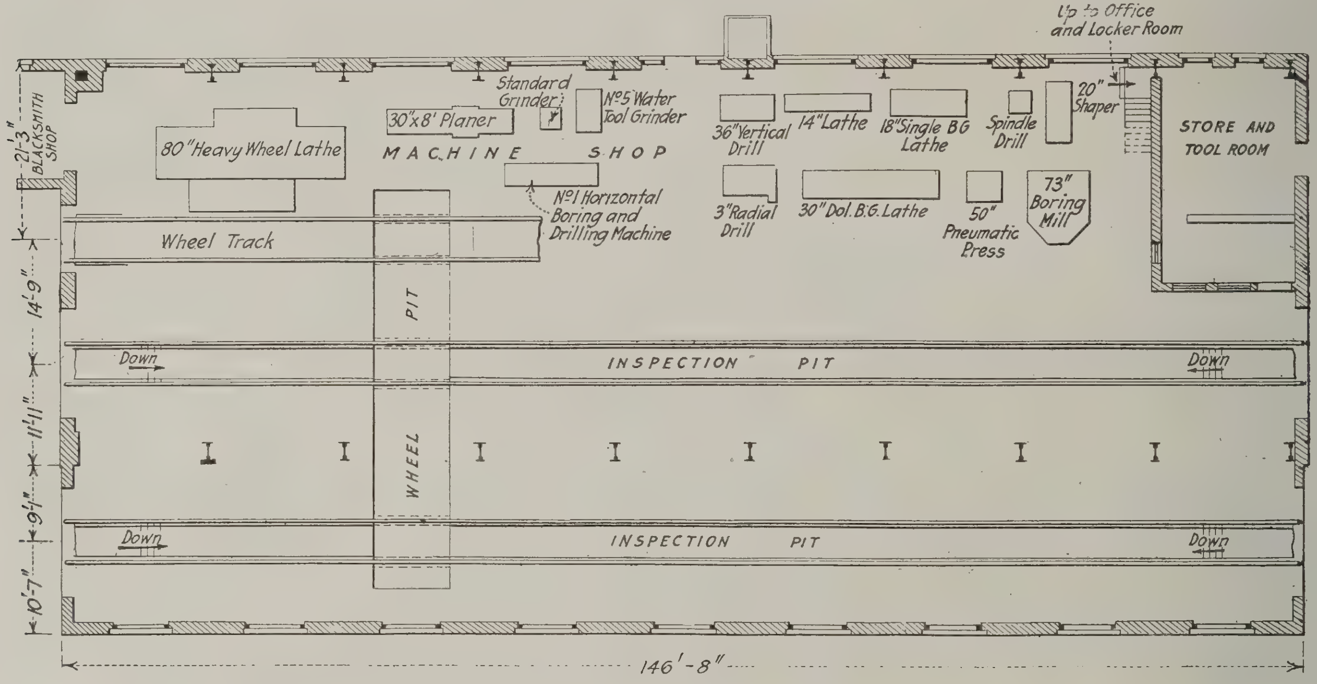


Fig. 4. Plan of Locomotive Inspection Building at Bluestone, Showing Location of Inspection Pits and Machine Tools.

When considering the question of providing proper maintenance facilities for the entire installation, it was decided that Bluestone was the logical site for the main locomotive inspection and maintenance building, because of its central location as regards the electric zone, and because the power plant was to be located there, near the only available water supply. The line maintenance force is also located at Bluestone in a brick building, formerly used as a pumping station.

The concentration of the various electric traction departments and the power supply at one central point is sure to result in a co-operation and an organization efficiency that could not be hoped for if the various facilities were scattered. The power director, who is located at the power house switchboard, is at the center of a web of telephone wires connecting him with the train dispatcher, division superintendent, signal bridges, yardmasters, line patrol telephones, line foremen, locomotive inspectors, etc., and in this way he acts as the final bond between all departments, thus completing a perfect operating and maintenance organization.

The locomotive inspection building at Bluestone is a substantial brick and steel structure 148 ft. by 68 ft., similar in style to the power plant. This building is shown on the right of the power house in Fig. 5. By referring to the floor plan shown by Fig. 4 it will be noted there are two inspection pits running the full length of the building, with a wheel pit connecting them with the wheel track in the machine tool bay. The inspection pits are of concrete, are well drained and are provided with numerous lighting, power and compressed air outlets. The wheel pit is equipped with a narrow gage track for the transfer of wheels between the locomotives and the wheel track, as they rust on a wheeled pneumatic jack.

The pit furthest from the machine bay is used almost exclusively for inspection purposes and to facilitate this inspection a platform, 112 feet long, and located 12 ft. 8 in. above the rails, has been erected near it.

All dissembly, erection and repair work is done over the other inspection pit and in the machine bay. This part of the shop is served by a 30-ton Whiting crane equipped with a 30-ton main hoist and a 5-ton auxiliary hoist.

Some of the machine tools installed in the machine shop are individually motor-driven and part are arranged for group drive from one motor-driven line shaft. All motors are of 220-volt, direct current. The machine tools installed are:

	Motor	
Description of tool.	H.P.	R.P.M.
MOTOR DRIVEN.		
80-in. driving wheel lather	50	500-1,000
73-in. boring and turning mill	2	1,200
	12	375-1,500
30-in. x 30-in. x 8 ft. planer	5	1,100
36-in. x 15-ft. engine lather	12.5	400-1,600
60-in. x 6-ft. boring and drilling machine (Hor.)	4	500-750-1,500
20-in. crank shaper	4	500-750-1,500
3-ft. radial drill	3	1,000
BELT DRIVEN GROUP.		
18-in. x 10-ft. engine lather 36-in. vertical drill 14-in., 2 spindle, sensitive drill 36-in. x 4-in. wet tool emery wheel Size c, Diamond double emery grinder	15	825

LARGE PNEUMATIC TOOLS.

600-lb. single frame hammer
45-ton rod brushing press
Wheel jack

In addition to the above a winch driven by a 15-h.p., 1,650-r.p.m. motor is located just outside of the western end of the shop for moving the locomotives being inspected or repaired.

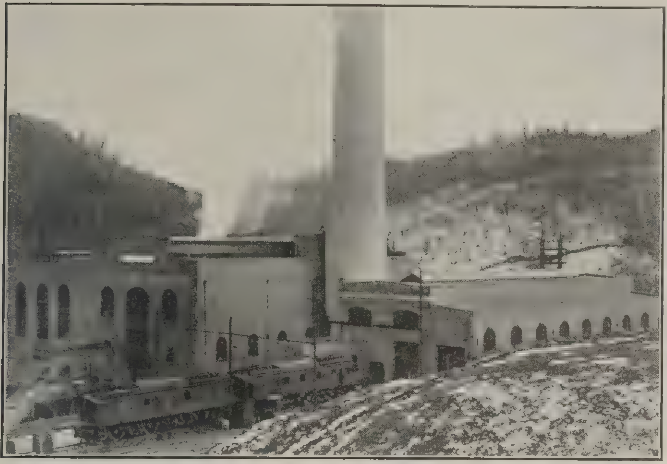


Fig. 5. Power House and Locomotive Inspection Building at Bluestone.

The overhead system of electric lighting is employed, with large tungsten lamps in enameled metal reflectors located on the steel roof trusses. A special feature of the lighting system is the use of 100 and 60-watt lamps in angle reflectors, which are mounted on the side walls, about 10 ft. from the floor. Extension cord receptacles are provided where necessary.

Locomotive Inspection.

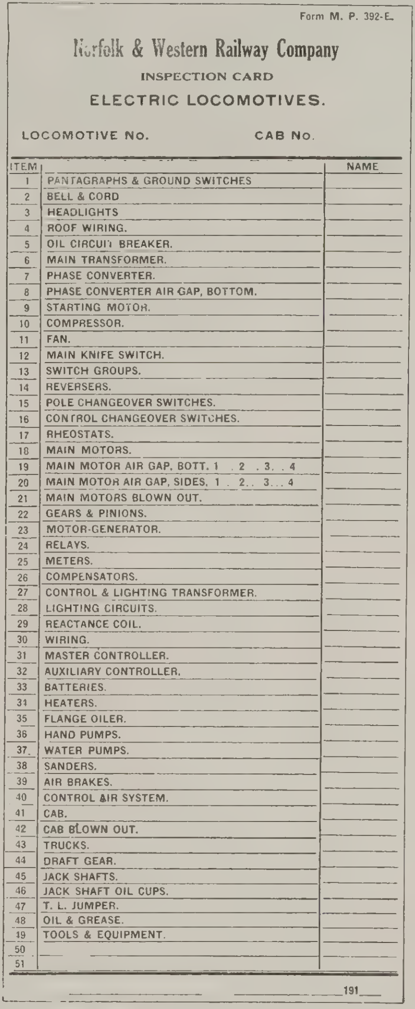
The general inspection routine requires under normal conditions that one locomotive be sent to the shop each day. Rotating the 12 locomotives, one after another, in this way insures that each one receives a general inspection every 12 days. Of course, extra heavy repairs upset this plan, but as a general thing it is closely followed. Immediately after a locomotive arrives in the shop it is given an inspection card, as shown in Fig. 7. As will be noted, this card gives a complete list of the locomotive parts to be inspected. Each man in the inspection force is permanently assigned to cover a certain number of these items, the total being divided between seven wiremen, one air-brake man, one machinist and one pipefitter. In this way the work for each man is automatically outlined in advance and no time is wasted giving routine instructions. When the card is hung on the locomotive the force of inspectors start to work and as the inspection of each item is completed the man responsible marks his initials after it in the column headed "name." Any fault found is immediately reported to the foreman inspector, who takes steps to have it corrected.

N. & W. ELECT'N.
NOS. OF CABS—ELEC. LOCOS.
: .m. — 191 .

LOCO. NO.	EAST CAB.	WEST CAB.
2500	E—...........	E—...........
2501	E—...........	E—...........
2502	E—...........	E—...........
2503	E—...........	E—...........
2504	E—...........	E—...........
2505	E—...........	E—...........
2506	E—...........	E—...........
2507	E—...........	E—...........
2508	E—...........	E—...........
2509	E—...........	E—...........
2510	E—...........	E—...........
2511	E—...........	E—...........

Gen'l Foreman Elect'n.

Fig. 6. The Form Used to Keep a Record of the Cab Numbers Assigned to Each Locomotive Number.



Form M. P. 392-E.

Norfolk & Western Railway Company
INSPECTION CARD
ELECTRIC LOCOMOTIVES.

LOCOMOTIVE No. CAB No.

ITEM		NAME
1	PANTAGRAPHS & GROUND SWITCHES	
2	BELL & CORD	
3	HEADLIGHTS	
4	ROOF WIRING.	
5	OIL CIRCUIT BREAKER.	
6	MAIN TRANSFORMER.	
7	PHASE CONVERTER.	
8	PHASE CONVERTER AIR GAP, BOTTOM.	
9	STARTING MOTOR.	
10	COMPRESSOR.	
11	FAN.	
12	MAIN KNIFE SWITCH.	
13	SWITCH GROUPS.	
14	REVERSERS.	
15	POLE CHANGEOVER SWITCHES.	
16	CONTROL CHANGEOVER SWITCHES.	
17	RHEOSTATS.	
18	MAIN MOTORS.	
19	MAIN MOTOR AIR GAP, BOTT. 1 . 2 . 3. . 4	
20	MAIN MOTOR AIR GAP, SIDES, 1 . 2. . 3. . . 4	
21	MAIN MOTORS BLOWN OUT.	
22	GEARS & PINIONS.	
23	MOTOR-GENERATOR.	
24	RELAYS.	
25	METERS.	
26	COMPENSATORS.	
27	CONTROL & LIGHTING TRANSFORMER.	
28	LIGHTING CIRCUITS.	
29	REACTANCE COIL.	
30	WIRING.	
31	MASTER CONTROLLER.	
32	AUXILIARY CONTROLLER.	
33	BATTERIES.	
34	HEATERS.	
35	FLANGE OILER.	
36	HAND PUMPS.	
37	WATER PUMPS.	
38	SANDERS.	
39	AIR BRAKES.	
40	CONTROL AIR SYSTEM.	
41	CAB.	
42	CAB BLOWN OUT.	
43	TRUCKS.	
44	DRAFT GEAR.	
45	JACK SHAFTS.	
46	JACK SHAFT OIL CUPS.	
47	T. L. JUMPER.	
48	OIL & GREASE.	
19	TOOLS & EQUIPMENT.	
50		
51		

191

Fig. 7. Inspection Card Used in Connection with the General Inspection of Electric Locomotives at Bluestone.

As each electric locomotive is made up of two distinct units or halves it is possible to take one-half of one locomotive and attach it to a half of another locomotive. In other words these units or halves are interchangeable. This arrangement has proved most convenient, because it often happens that two locomotives require repairs to only one of these units at the same time. By the simple expedient of coupling the two good halves together, one good locomotive is made from two which would otherwise be unfit for service. Such a practice necessarily requires some special system for keeping the locomotive numbers straight. The system used is to give permanent distinctive numbers to the cabs (as the units are called) and temporary numbers to the entire locomotive of two cabs. The cab numbers are on a brass plate riveted to each end of the cab on the inside and consist of the letter E and a number. The locomotive numbers are on removable plates hung on the outside of each cab. A record showing the cab numbers assigned to each locomotive number, as shown by Fig. 6, is kept and each time a change is made, copies of the corrected list are sent to the officers interested.

The maintenance facilities at Bluefield, where terminal inspections and light running repairs only are made, consist of a small frame building containing an office, an oil room, a locker and wash room and a store room. An open air inspection pit and six elevated sand boxes are also provided. The day inspection and maintenance force at Bluefield consists of an inspector, a clerk, a wireman, a machinist, a pipe fitter, an oiler, and three laborers. The night force consists of a machinist, a pipe fitter, an oiler and two laborers. Except for the electric light wiring, no inspection is made of the electric apparatus at night. The locomotives are expected to be ready for service after a layover of 40 minutes at Bluefield, except in cases requiring extraordinary repairs. This means that a locomotive is laying over for inspection only about two hours out of every 24, or about 8 per cent of the time.

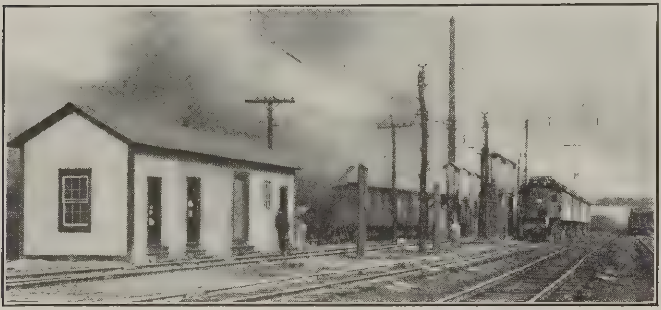


Fig. 8. Locomotive Inspection Facilities at Bluefield. A Pit, Which Cannot be Seen is Located in the Second Track in Front of the Frame Building.

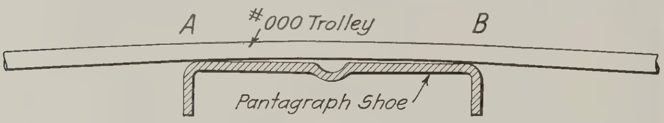


Fig. 9. Sketch Showing How the Upward Thrust of the Pantagraph Shoe Curves the Trolley Wire so that it Makes Contact with the Shoe at Points A and B Only, Thus Causing Greatest Wear at Those Points.

Locomotive Performance.

In general, it can be said that the locomotives have more than come up to expectations in their ability to stand up under the most severe traction conditions in the world, and considering the racking service and the fact that these are the first locomotives built to haul such enormous trains over heavy grades, their performance has been remarkable. No tires have been replaced since electric operation was inaugurated in May, 1915. Any flat spots that have appeared have been filled up by electric welding and then ground off to the proper contour.

The solution in the water rheostats (water and soda ash) is renewed about once a week. The renewable steel pantagraph shoes have a serviceable life of from two to three months, the greatest wear taking place along the edges of the shoe (see points A and B, Fig. 9). This is evidently because its contact surface is flat, whereas the trolley wire, at the point of contact, takes the form of a long radius arc due to the upward thrust of the pantagraph. This condition is of course exaggerated in the sketch. It is usually found that while the shoe wears through along the edge, the metal near the center is hardly touched.

Line Maintenance.

The headquarters for the line inspection and maintenance force is located at Bluestone in a brick building formerly used as a pumping station. In addition to the office of the line foreman this building contains a storeroom for a complete supply of line material. The construction and maintenance facilities consist of a repair and construction train made up of a tower car, tool car and several flat cars for poles, wire reels, etc. The tool car is fitted with a grounded standard pantagraph, which is used as a safety ground, as well as for gaging the height and position of the trolley wire. This construction train has been used but three times since last fall and then only for new construction work, involving trolley extension into branch lines or over additional side tracks, etc., and for trolley adjustment.

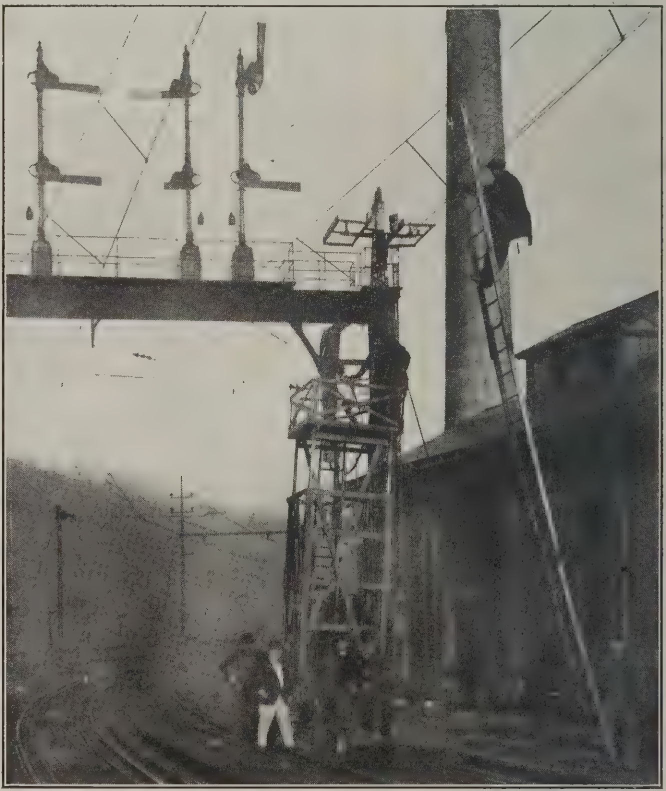


Fig. 10. Line Inspection and Repair Outfit Set Up Ready for Work. The Man On the "Hot-Ladder" Has His Hand On a Live, 11,000-Volt Trolley.

A small platform car and treated extension ladders are used for ordinary repairs. The tower on the platform car is telescoping, the upper half being raised to the proper height by two sets of pulley-blocks. This platform car is pulled behind an ordinary gasoline car. The outfit, which is shown in Fig. 10, is very light and easily assembled and may be quickly sent to any part of the line. It is manned by small gangs of not more than five men, consisting of four wiremen and a flagman. The maintenance of the entire line is taken care of by two such crews, one at Bluestone and one at Bluefield. The entire line is inspected daily by one man who generally rides the locomotives.

Patrol telephones, in locked iron boxes, are located on each west signal bridge, which are about one mile apart. These telephones, which connect with the power director at the power house, are used by the maintenance crew and section foremen for reporting trouble, completion of repairs, etc. In addition, each line crew has a portable telephone set, which may be tapped on to the through telephone line.

All section foremen have been instructed to call up the power director when rails are to be removed, so that arrangements can be made to have the line crew go out and take care of the bonding. Usually the section foreman carries a sufficient number of long jumpers, which are bolted to the bonds on each side of the new rail. When such a jumper is used it is left connected until the bonding crew installs the permanent bonds later.

Bond-Hole Drilling Outfit.

The device shown in Fig. 11 is used by the line construction and maintenance force for drilling bond-holes in the rails. It consists essentially of an angle iron attached to the bottom of the rail by two threaded hook-bolts. This angle iron forms a back or "old man" for the hand ratchet brace, as shown in the sketch, and is long enough to allow the drilling of one hole on each side of the fish-plates. The rope, which is tied to one of the hook-bolts, is given a few turns around the hand feed on the brace and is used to hold the feeding device when additional pressure is required on the drill point. The feeding device could be operated by hand, but the rope is easier and less awkward to operate. A padded wooden seat used in connection with this outfit has a projection on its lower side at one end so that the seat is level when one end is placed on the rail and the other end on the ties.

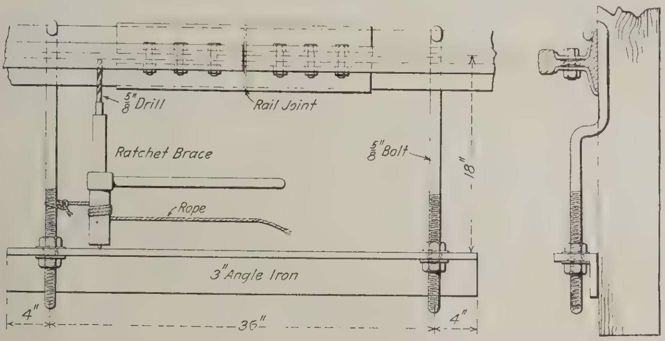


Fig. 11. Apparatus Used by the Line and Track Bond Maintenance Force for Drilling Bond Holes in the Rail. It is Simply Necessary to Drop the Ratchet Brace Handle When a Train Passes.

This outfit is not only fast, but is convenient for use on the main line where trains may be expected any time. When a train approaches it is simply necessary to take the seat off the track and throw the ratchet handle down parallel with the rail, an operation requiring but a few seconds and one that does not disturb the drill.

In general, the overhead catenary system has given perfect satisfaction and this fact furnishes ample proof that the light, flexible catenary systems give the best results, even under the most severe conditions. Some trouble has been experienced because of changes in the super-elevation of the track on curves, but this was due mostly to lack of knowledge of the results on the part of the section foremen. Since the section foremen have been "lined up" on this point, there has been no further trouble.

In one or two isolated cases the suspension insulators have flashed over, due to an accumulation of wet snow and soot, but trouble from this source is surprisingly infrequent. The wearing effect of the pantagraph shoe on the trolley wire is small. A piece of trolley wire which was removed from the Elkhorn tunnel after eight months of continuous service showed a flat spot of about 1/16 in. wide.

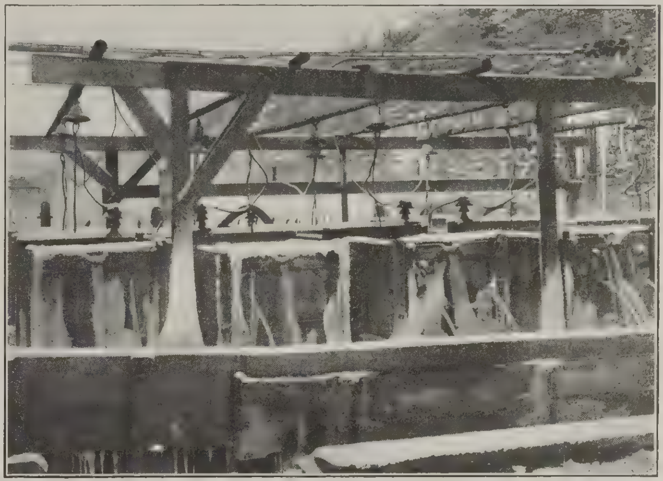


Fig. 12. The Improved Type of Regeneration Load Water Rheostat. The Water Is Admitted Through the Fiber Conduit which Rests On 11,000 Volt Insulators as Shown at the Back of Each Box.

Regeneration Loading Rheostats.

Ordinarily the power regenerated by a train going down grade is absorbed by locomotives working at other points on the system. There are times, however, when the regenerative power is greater than the load and if no other load was provided the excess would reverse the power plant generators and run them as motors. To prevent this, a loading rheostat was originally installed, consisting of electrodes immersed in the intake canal. This rheostat was connected to the power plant busses by automatically operated oil switches controlled by reverse current relays.

Recently a new and improved type of regenerative loading rheostat has been installed, as shown in Fig. 12. There are two separate rheostats, each made up of three 15-ft. boxes, 2 ft. square in section, and resting on 44,000 pin insulators. The three boxes, which are 4 ft. between centers, are connected in parallel. Fresh water is fed in at one end of each box through 3-in. Orangeburg fiber conduit, which rests on 11,000 volt pin insulators, as shown in the illustration. The water flows out through numerous holes in the opposite end. The holes near the bottom, where the pressure is greatest, are smaller than those above, and in this way the water is made to move with a uniform velocity through the entire section of the box. There are two electrodes in each box, consisting of 5-in. channel irons, 15 in. long. They are hung from suspension type insulators fastened to sections of iron pipe resting on a wooden frame work. The high tension electrodes are connected to the 11,000 volt leads from the powerhouse, which pass overhead and which are dead-ended on a pole by three-unit suspension insulators. The grounded electrodes are connected to a ground plate.

Each rheostat (three boxes) is designed to carry 500 k.w. at 11,000 volts. The capacity is varied, when necessary, by shifting the electrodes horizontally. As the conductivity of the water changes with different seasons of the year it is necessary to provide for proper adjustment of these rheostats. The small cross section of the boxes in the new rheostats make such an adjustment possible. Two rheostat circuits were provided to take care of the variable excess regenerative current and to facilitate the cleaning or repairing of one without taking both out of service.

A New Lower Deck Car Lighting Fixture

The steel dining cars and coaches recently received by the Northern Pacific from the Pullman Company are equipped with a new style of lower deck lighting fixture, which in design and application is a distinct departure from other fixtures of the flush type.

The new fixture was developed by the Adams & Westlake Company at the request of the railroad company. In brief the specifications were to design a fixture, which, when flush mounted along each lower deck rail, would amply illuminate, without glare and without the use of additional fixtures, both the reading plane and the ceiling. The most difficult feature of the design was to determine the form and curvature of the glassware necessary to eliminate shadows on the ceiling, as it was a simple matter to provide proper illumination on the reading plane. The design shown in Fig. 1 was finally adopted and, when installed as shown by Figs. 2 and 3, the results were satisfactory.

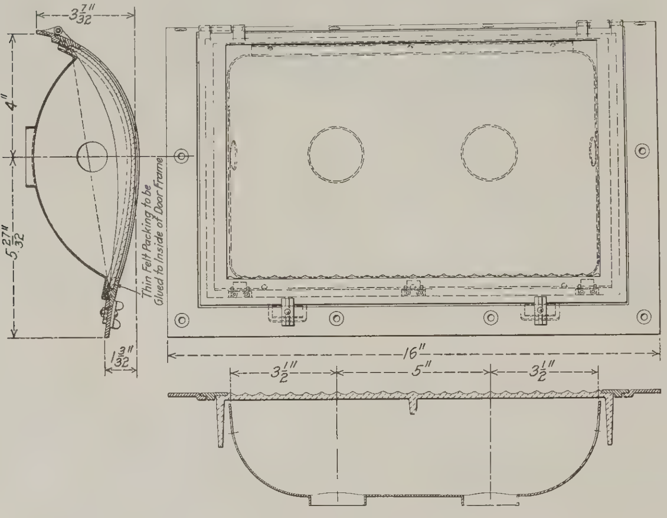


Fig. 1. Details of Glass and Frame of New Car Lighting Fixture. The Application of the Two Lamps is Shown in Fig. 2.

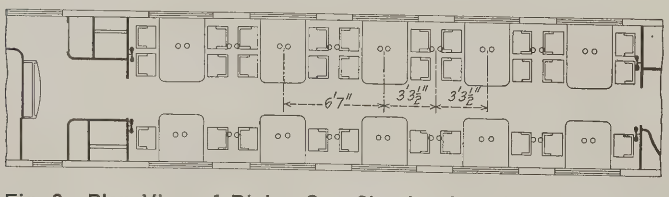


Fig. 2. Plan View of Dining Car, Showing Locations of the New Style of Lower Deck Fixtures.

Design.

By referring to Fig. 3 it will be noted that the complete fixture is built up by mounting two Bryant No. 42453 molding base receptacles on two wrought iron straps screwed to the framework of the car. Next a curved silvered reflector with two holes for exposing the receptacles is screwed to the car, and over all is screwed a brass frame holding a diffusing glass in a hinged door. The details of the reflector, frame and glass are plainly shown in Fig. 1. The small hole at each end of the reflector is for ventilation. As shown in Fig. 3 the contour of the lower deck has been made to conform to the curve of the fixture, thereby eliminating corners or dark pockets and producing on the whole a symmetrical and pleasing effect.

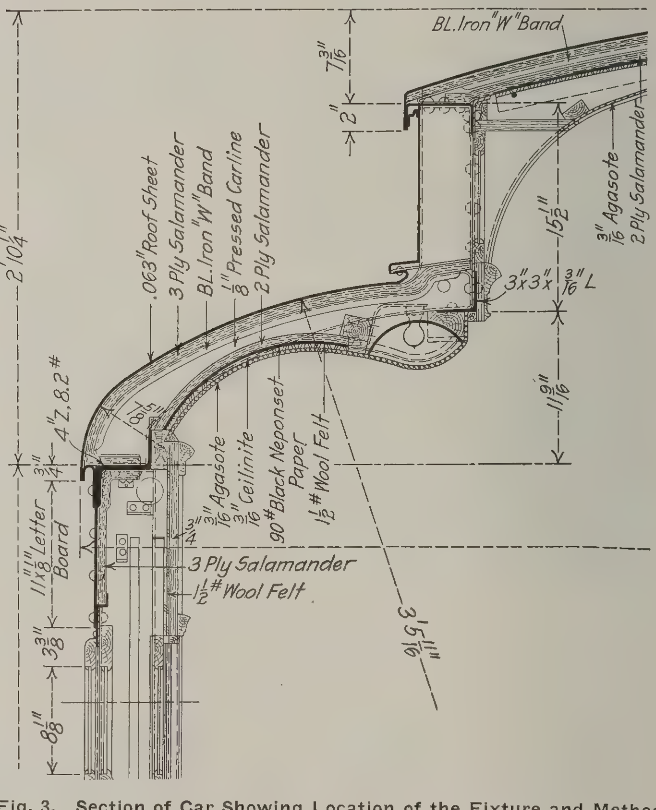


Fig. 3. Section of Car Showing Location of the Fixture and Method of Installing the Sockets and Lamp Bulbs.

Each fixture is fitted with two 15-watt lamps and in the diners, as shown in Fig. 2, the distance between fixtures is 3 ft. 3½ in. In the coaches the fixtures are located every six feet, or opposite the center post of each window. There are 18 fixtures in the body of the 10-table dining cars and 22 fixtures in the body of the standard 70-ft. coaches.

Maintenance.

If it becomes necessary to replace the electric lamp bulbs or the glass in one of these fixtures the only operation necessary is to turn the two wing latches shown at the bottom of the end section in Fig. 1 and let down the hinged portion of the brass frame in which the glass normally rests, being held in place by six small leaf springs. The lamps will then be exposed and may be easily replaced.

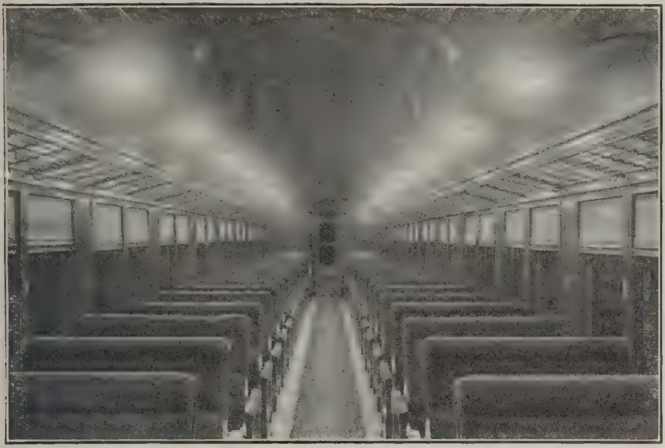


Fig. 4. View of Coach Interior Taken at Night with Its Own Illumination.

When the car goes through the shop for general overhauling the only part of the fixture that requires attention is the brass frame, which can be easily taken down. It is not necessary to touch the receptacles or the wiring, as they are permanently attached to the framework of the car. The same is true of the reflector, which, being silvered, should retain its polish indefinitely.

The absence of fixture wire in these fixtures should also result in freedom from grounds such as frequently occur when this small wire is pulled through the restricted openings sometimes found in other forms of fixtures or when brass sockets are used.

Unfortunately, photometer readings of the illumination in the cars equipped with these fixtures are not available, but the illustrations in Figs. 4 and 5 show, to some extent, the results obtained. The absence of glare and shadows and the softness of the light is particularly noticeable.

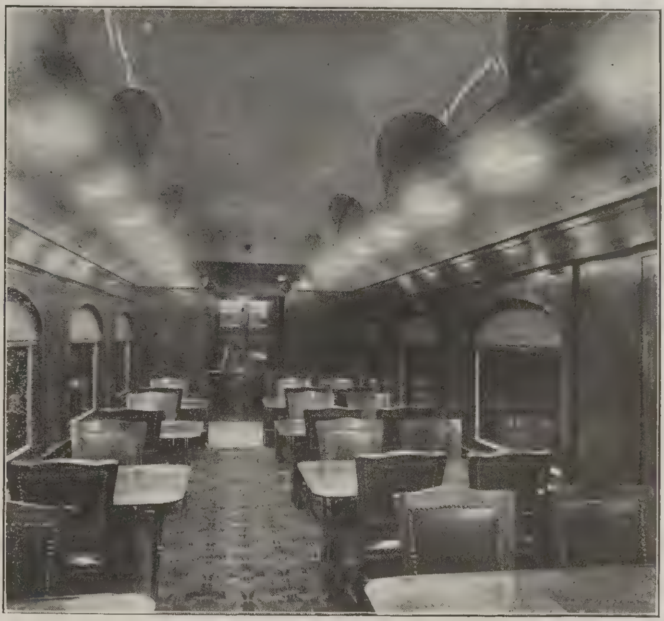


Fig. 5. View of Dining Car Interior Taken at Night Without Flashlight. Note the Absence of Glare and Shadows.

A Code for Better Lighting*

II

Believing that the proper illumination of railway offices, depots, shops, freight warehouses, docks, etc., is a most important factor in preventing accidents, in producing greater accuracy of workmanship and in increasing labor efficiency, we are reprinting, in short, readable articles, a Code of Lighting, prepared by committees of the Illuminating Engineering Society. This code is a practical summary of information pertaining to the illumination of shops and other work places.

The first article appeared in the January issue.

EXPLANATORY NOTES.

Section I. Daylight.—Adequate daylight facilities through large window areas together with light, cheerful surroundings, are highly desirable and necessary features in every work place, and they should be supplied through the necessary channels not only from the humane standpoint, but also from the point of view of maximum plant efficiency.

Importance of Daylight.—The unusual attention to gas and electric lighting in factories, mills and other work places during the past few years; the perfection of various lamps and auxiliaries by means of which an improved quality and quantity of lighting effects are obtained; and the care which has been devoted to increasing the efficiency in various industrial operations—all go to emphasize the many advantages and economies that result from suitable and adequate window space as a means for daylight in the proper quantities and in the right directions during those portions of the day when it is available.

Three Considerations.—Three important considerations of any lighting method are *sufficiency, continuity* and *diffusion.* With respect to the daylight illumination of interiors, *sufficiency* demands adequate window area; *continuity* requires (*a*) large enough window area for use on reasonably dark days, (*b*) means for reducing the illumination when excessive due to direct sunshine. and (*c*) supplementary lighting equipment for use on particularly dark days and especially towards the close of winter days; *diffusion* demands interior decorations that are as light in color as practicable for ceilings and upper portions of walls, and of a dull or mat finish in order that the light which enters the windows or that which is produced by lamps may not be absorbed and lost on the first object that it strikes, but that it may be returned by reflection and thus be used over and over again. Diffusion also requires that the various sources of light, whether windows, skylights or lamps, be well distributed about the space to be lighted. Light colored surroundings as here suggested result in marked economy, but their main object is perhaps not so much economy as to obtain a result that will be satisfactory to the human eye.

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* Code copyrighted by the Illuminating Engineering Society.

Requirements.—The following requirements may now be listed for natural lighting:

1. The light should be adequate for each employee.
2. The windows should be so spaced and located that daylight conditions are fairly uniform over the working area.
3. The intensities of daylight should be such that artificial light will be required only during those portions of the day when it would naturally be considered necessary.
4. The windows should provide a quality of daylight which will avoid a glare due to the sun's rays and light from the sky shining directly into the eye, or where this does not prove to be the case at all parts of the day, window shades or other means should be available to make this end possible.
5. Ceilings and upper portions of walls should be maintained a light color to increase the effectiveness of the lighting facilities from window areas. The lower portions of walls should be somewhat darker in tone to render the lighting restful for the eye. Factory green or other medium colors may be used to good effect.

Classification.—Means for natural lighting may be classed under three broad divisions as follows:

(*a*) That case in which the windows are located on the sides of the building or in the framework of saw-tooth construction, where diffused light from the sky reaches the work during a large portion of the day.

(*b*) That case in which windows are located overhead on a horizontal or nearly horizontal plane in the form of skylights, thus furnishing direct light from the sky during a large portion of the day.

(*c*) That case in which prismatic glass takes up the direct light from the sky and redirects it into the working space.

Method (*a*) is, of course, the most common of the three, and it may be noted that the saw-tooth or other roof lighting constructions have become very popular and result in an excellent quality and quantity of light for given window areas provided the size, design and location of windows are in accord with the best modern practice.

Increasing the Value of Floor Space.—Adequate and well distributed natural light means that certain portions of the floor space which ordinarily would not be available for work, are converted into valuable manufacturing space. In a general way, therefore, the average factory, mill or other work place, if properly designed, should possess natural lighting facilities which produce the best practicable distribution of daylight illumination.

Wide Aisles.—With low ceilings and very wide aisles, workmen located at the central portion of the building must sometimes depend for their natural light on windows located at a considerable distance away from their working position. In these cases it may be impossible, in general, to depend altogether on daylight over an entire floor space, even at those times of the day when daylight conditions would be entirely adequate under other circumstances. This statement applies to side windows rather than to skylights or to saw-tooth construction. Fig. 1 illustrates this feature.

Varying Conditions.—In a case of this kind, employees located next to the windows are furnished with suitable daylight in the early morning and towards the latter part of the afternoon, the upper portions of the windows being particularly serviceable in lighting areas at some distance away from the windows. A southern exposure, however, results in such excessive light from the sky during the middle of the day, that heavy shades are nearly always pulled down so as to cover the entire window area. This plan makes it necessary to use artificial light throughout the larger part of the office during the brightest portion of the day, and reduces the daylight at those points where it would supposedly be the best, namely, near the windows. Here the location of the windows is a large factor in the excellence of the daylight conditions, but the manipulation of the shades is perhaps even more important. To avoid such a difficulty, adjustable translucent upper window shades with adjustable opaque lower shades might be employed.

Upper Portion of Windows.—It should be further noted in this illustration that the upper portions of the windows give a reduced illumination in proportion to their areas, to the floor space near them. In rooms of moderate size, therefore, the windows should be placed as near the ceiling as practicable. When the sun shines through windows so located, the direct light must be reduced or diffused. This may be accomplished by the use of ribbed glass in ordinary factory and mill buildings, and in offices by the use of translucent sun shades or awnings.

Tempering the Light.—The light due to the sunshine on such shades and awnings will be as bright as ordinary skylight if the shade is well chosen, and the ribbed glass will be still brighter. If the windows are large, the illumination is likely to be too great near the windows as previously pointed out and it must be reduced. This should not be done, however, by pulling down an opaque shade over the top of the windows because the top portion of the window is the part that is particularly needed to give light to the interior of the room. The better scheme is to employ an opaque shade *which should be raised from the bottom of the window.* This will considerably reduce the illumination near the window without affecting it over the interior of the room to any marked degree.

Bench Locations.—Fig. 2 shows how benches are commonly located with respect to windows, so that the light received on the work may be most satisfactory. This sets a certain limitation upon the possible arrangement of the work over the floor space, depending on the way the daylight is furnished to the floor area. This limitation can be eliminated almost completely in the case of artificial light through a uniform distribution of lamps overhead. This statement applies to those cases where natural light is transmitted through side windows, and includes a feature specially noticeable in buildings of more than one story. In contrast, the work may be arranged almost independently of the natural light in buildings where the natural light is furnished by overhead windows or through the means of saw-tooth construction.

Window Glasses.—Both translucent and clear glass are employed for factory and mill windows. There is a slight reduction in the transmitted light through ordinary translucent wire glass, but it is often required by insurance regulations for a reduction in the fire risk where a given building is located in close proximity to other buildings. Wire glass is also used quite generally with steel window frames, here being an added protection from the standpoint of fire risk. Wire glass may be obtained in clear form, but its expense in contrast to the translucent form is such as ordinarily to prohibit its use for industrial purposes.

Wire Glass.—Wire glass, also known as ribbed glass, should be used and is advocated for practically all factory and mill windows where prisms are not required. Wires of rather open mesh cause so little reduction in light as to warrant no mention of this feature. Special care should be taken to get such glass as is smooth both on the flat side and on the ribbed side to facilitate cleaning. Wire or ribbed glass gives better diffusion than plain glass.

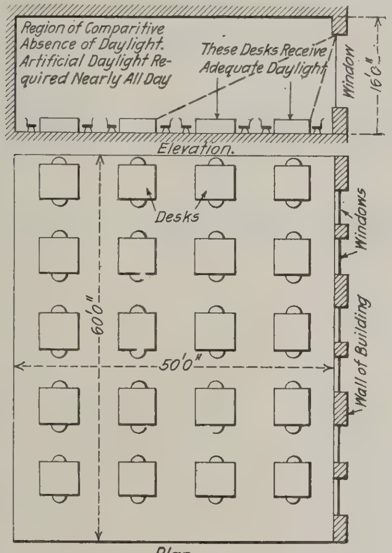
Region of Comparitive Absence of Daylight. Artificial Daylight Required Nearly All Day
These Desks Receive Adequate Daylight
Window
16'0"
Elevation.
Desks
Windows
60'0"
50'0"
Wall of Building
Plan.

Fig. 1. Diagram of a Large Office with Windows on One Side Only.

Prism Glass.—Where the sky outside of the windows is obstructed by buildings, prism glass is recommended if the room is deep. Different kinds of prisms cannot be used to advantage interchangeably. The amount of prism glass required in any case depends much upon the surroundings and to obtain excellent results, of which such glass is capable, it must be used intelligently.

Skylights.—Skylights are sometimes installed in long narrow continuous strips in a sloping roof. The ribs of the ribbed glass are generally so arranged that it is convenient to make them at right angles to the length of the strips. The result is that the sunshine is diffused by the ribs over a narrow area parallel to the strip of skylight, thus lighting one part of the room much more brilliantly than the remainder. If the ribs are installed to run parallel to the strips, they will give a much more general distribution of the sunlight. In the foregoing, the word *strip* refers to the long belt of skylight and not to the individual sheet of glass. Ribbed glass in vertical windows should generally be placed with the ribs horizontal. They thus roughly fulfill some of the functions of prisms

Dirt Accumulations.—While translucent wire or ribbed glass reduces the amount of light transmitted through the windows, the roughness of the outside surface of such glass often causes accumulations of dust and dirt, which are more to blame for the reduction of transmitted light in some cases than the translucent nature of the glass itself. Remedies of this difficulty are to secure smooth glass and to resort to frequent cleaning.

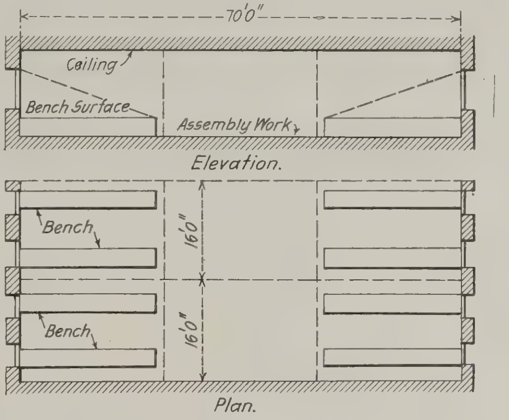

Fig. 2. Diagram Showing Benches Located with Respect to the Windows so as to Receive the Natural Light Advantageously.

Wire Glass as a Safeguard.—Wire glass for skylights is, of course, a practical necessity as a safeguard against accidents due to accidental breakage of the glass or due to objects falling on top of the glass.

Calculations for Natural Light.—In certain typical localities, the average brightness of the sky during business hours is about 250 candles per square foot. This is probably a fair average value for the entire United States. The lower or minimum value of sky brightness, excluding particularly stormy days, may be taken as about 100 candles per square foot. Allowing for a reduction of 25 per cent for losses in the windows themselves, the brightness of the sky as seen through a window becomes equal to a minimum of say 75 candles per square foot in any directions from which the sky can be seen through the windows. This brightness value if multiplied by the part of the window area through which sky is visible from a given point in the work space gives the available candlepower through the window in question, and this candlepower is then divided by the square of the distance between the given point and the window to obtain the foot-candle intensity of the illumination at the given point.

Method Illustrated.—To illustrate this method, consider a hallway 40 ft. long, lighted by a window 5 ft. by 5 ft. at one end, with the sky visible from the darker end of the hall through the upper half of the window only. The illumination at the dark end of the hall will then be equal to:

$$5 \times 5 \times 0.5 \times \frac{75}{1,600} = 0.58 \text{ foot-candles,}$$

under the assumed window brightness of 75 candles per square foot. The 1,600 in this calculation results from the square of 40 ft., the length of the hall, or in other words the distance from the point considered to the window; and the factor 0.5 takes into account the fact that the sky is visible through only one-half of the window area from the point considered.

Checking the Intensity.—The intensity is not sufficient at this darkest part of the hall since the requirements of Article I of the Code proper call for three times the minimum values given in Article V, and the minimum value given in Article V for passageways is 0.25. Three times this value is 0.75, which is somewhat greater than the value found in this calculation. The window area must therefore be increased in size by about 50 per cent., or if this is impossible or impracticable, the hallway must be provided with artificial light at those points where the natural light falls below the requirement.

Calculation for a Skylight.—As another illustration, assume that fine manufacturing work is to be performed under a skylight 20 ft. above the work. If the brightness is assumed to be 75 candles per square foot as before, the minimum intensity must be 3 × 3.5 foot-candles; that is, 10.5 foot-candles, based on the requirements of Article I of the Code. The window area must then equal:

$$10.5 \times \frac{75}{400} = 56 \text{ sq. ft.}$$

Part of Wndow Area to Consider.—It is important in estimating the illumination of any workroom to consider only that portion of the window area through which clear sky is visible, provided the window is equipped with ordinary clear glass.

Sunshine Not Desirable.—In all the work of providing natural light, it should be kept in mind that direct sunshine in itself, from the illumination standpoint but irrespective of sanitary conditions, is not wanted. The idea that sunshine is the important item is a common but an erroneous impression. For example, in saw-tooth construction, the windows do not face the south to get all the sunshine possible, but they face the north to exclude the sunshine. Ordinary windows, on the other hand, face all directions because not enough light can be distributed to interiors from north windows alone.

Shop Motor Section

The Operation of Feeder Voltage Regulators

J. H. Wickman*

XV

The connections of feeder voltage regulators are made on a terminal board on the top of the case, both for the stator and rotor elements. A small motor mounted on the top of the regulator is used for turning the rotor, although it can also be operated by means of a hand wheel. In either case the rotor of the regulator is moved by means of a worm gear fastened to either the motor or hand wheel. A two or three-phase motor is generally used on account of the ease with which a polyphase motor can be reversed.

Feeder regulators may be hand or automatically operated. If hand operated, the operator either turns the rotating elements by means of the hand wheel on the regulator or he has a reversing switch on switch board which controls the small motor on the regulator. The motor method of operating the regulator is far superior to the hand wheel method. When motor operated, the motor is controlled by a small double pole or triple pole, double throw switch located at any convenient point, usually near the volt meter, so the operator can see how much he raises or lowers the voltage. Closing the switch one way will cause the motor to turn the rotor of the regulator in one direction and closing it the other way will cause the motor to turn the rotor of the regulator in the reverse direction.

As the regulator rotor is designed to move through only part of a circle, a limiting device must be provided, so that it will not be turned past the extreme position in either direction. The limiting device on the hand operated regulators consists of stop-irons located on each end of the semi-circular worm gear that turns the motor. On the motor operated regulators a limit switch is provided which opens the motor circuit as soon as the regulator has reached either extreme position.

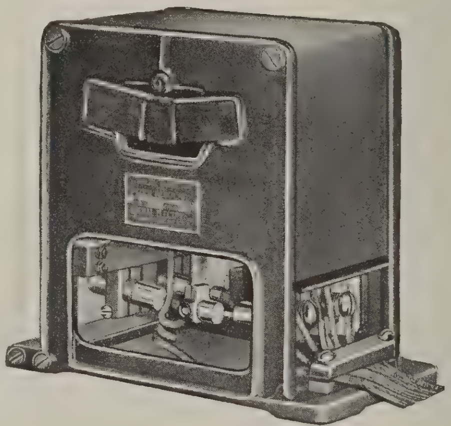

Fig. 37—Relay Switch Used for Controlling Automatic Feeder Voltage Regulators. The Carbon Contacts May Be Seen Through the Glass Front

This limit switch does not interfere with the movement of the regulator in the opposite direction after it has been opened, and it automatically closes as soon as the regulator rotor has been moved out of the extreme position, which caused the limit switch to open.

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All quick operating regulators are provided with a brake coil, which is connected across one phase of the motor circuit. The brake is always set by a spring when there is no current flowing through the motor, but when current is switched on it energizes the brake-coil, which overcomes the power of the spring and releases the brake.

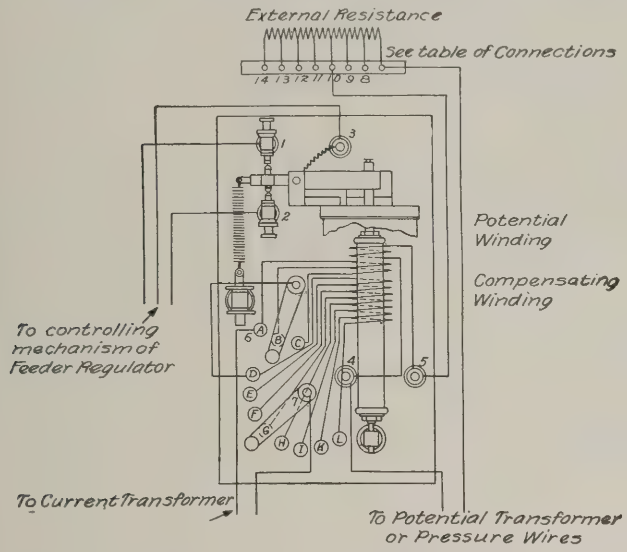

Fig. 38—Wiring Diagram of a Contact-Making Voltmeter Used in Conjunction with a Regulator Relay

Automatic Regulators.

Instead of a hand operated, triple pole, double throw switch, the automatic type of regulator is provided with a switch which is electrically operated by a relay and a contact—making voltmeter, connected across the regulated feeder. A relay switch, of the type used for automatic regulation, is shown in Fig. 37. Such a switch has six contacts and two alternating current magnets with opposite poles and a common armature. A wiring diagram for the contact-making voltmeter used in conjunction with the relay is shown in Fig. 38. It will be noted that it consists essentially of a solenoid and a laminated core, the latter being supported partly by a spring and partly by the current passing through the solenoid. This solenoid operates a lever which makes contact from either above or below; the contact above closes the relay circuit, which operates the regulator motor in one direction and the contact below closes the relay circuit, which operates the regulator motor in the opposite direction. When the line voltage is normal the lever stands in mid-position between the two contacts, but any variation of voltage will cause the lever either to rise or fall, thereby closing one of the relay circuits, which will close the regulator motor circuit. The motor will turn the regulator rotor until the voltage is adjusted to a predetermined value.

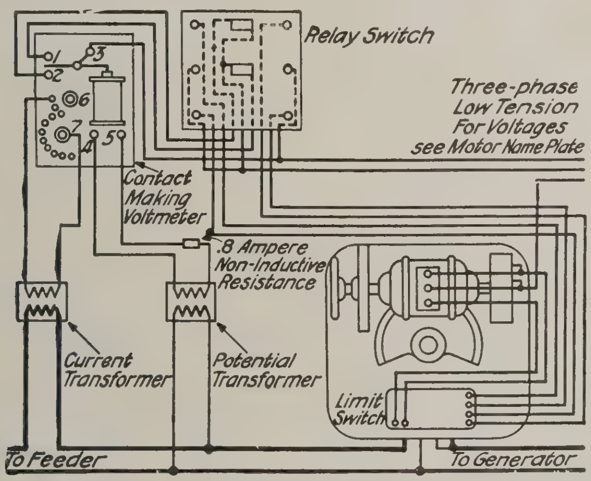

Fig. 39 — Diagram of Connections of a Single-Phase Feeder Regulator Automatically Operated by a Three-Phase Induction Motor

If it is desired to compensate for line losses so as to keep the voltage constant at some distant point on the feeder, it is necessary only to provide the contact-making voltmeter with an extra compensating winding connected in series with the line through a suitable current transformer. The compensating winding is usually connected through a dial switch so that the control can be adjusted very accurately and for different losses. Detailed connections of a voltmeter with a compensating winding (which is described in another paragraph) are shown in Fig. 40.

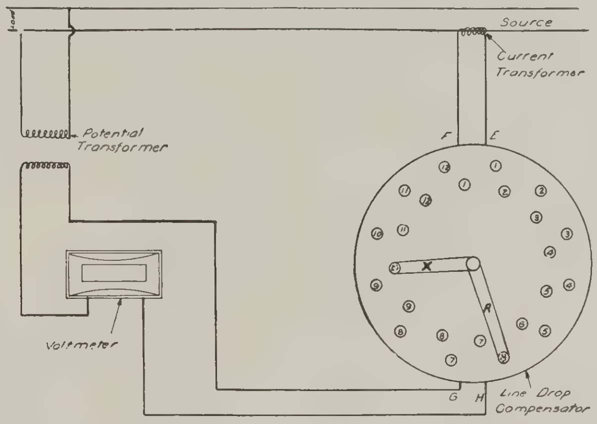

Fig. 40—Connection Diagram of a Voltmeter Provided with an Extra Compensating Winding

A diagram of the connections that would be used to connect a single-phase regulator, so that it will be automatically operated by a three-phase induction motor is shown in Fig. 39, while Fig. 41 shows a direct current control system applied to the same regulator. The connections used on a three-phase regulator, connected so that the line losses will be compensated for, are shown in Fig. 43. These connections are self-explanatory and need no further comment.

Hand Operated Regulators.

Another type of regulator that is often used in small stations, where there are only a few feeders to keep regulated and where the load is small, is the hand operated regulator. It is used almost entirely on single-phase lighting feeders and is composed of two coils wound similar to a transformer. The secondary winding has several taps taken out from it that connect to the several points shown on the dial switch, which is part of the wiring diagram for this type of regulator, shown in Fig. 42.

These regulators are so connected that when the dial switch has made one complete revolution the voltage of the line is equal to that of the generator. Continuing to turn the switch in the same direction will cause a reversing switch on the back of the regulator to close so that the next revolution of the dial switch, if in the same direction, will cause a boosting effect. Therefore, by two complete revolutions of the switch, the line voltage will be varied from the maximum buck voltage to the maximum boost voltage. These regulators are more efficient than the induction type, because the variation in feeder voltage is caused by cutting in and out coils of the secondary winding, whereas voltage variation with the induction type is caused by inductive action between the primary and secondary coils.

The selection of a regulator is important and the selection of a particular type should be made only after a careful study of the operating conditions.

A choice must be made between the single and polyphase types and it must be decided whether the regulator is to be hand or automatically operated. If the automatic type is installed it means that a good operator must be in charge, while the hand operated regulator can be operated by most any one by referring to a load chart. A load chart is a table showing what voltage should be maintained with various feeder currents. The automatic type is preferable, however, from the viewpoint of economical operation, which is important where revenue is figured closely.

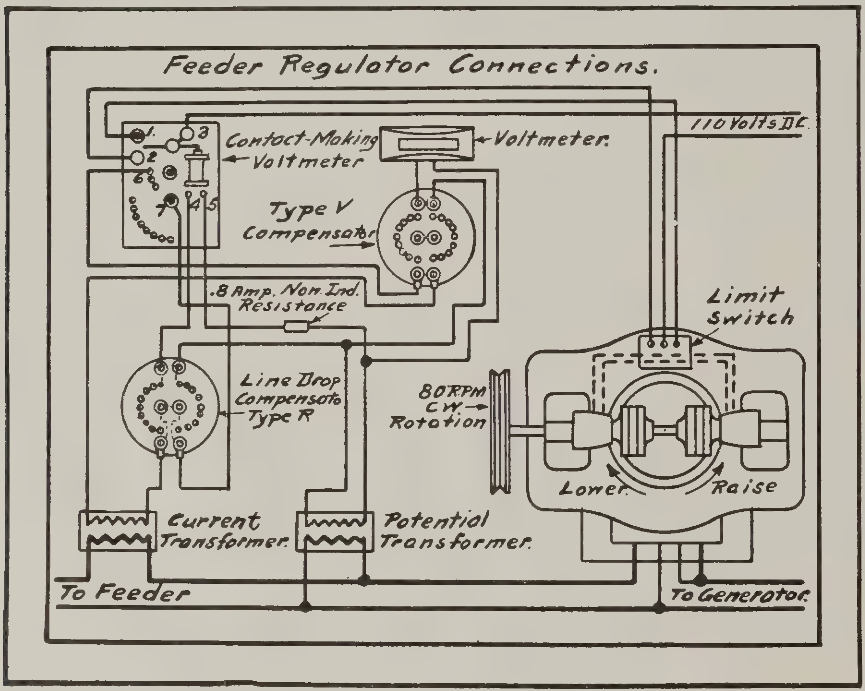

Fig. 41—Diagram of Connections of a Single-Phase Feeder Regulator Automatically Controlled by a Direct Current Motor

Operating Instructions.

Before any regulator is connected care should be taken to see that the current capacity of the regulator is sufficient to carry the load that is carried on the circuit. This information can always be determined by consulting the ammeter on the circuit and the name plate on the regulator, which gives the voltage, frequency and current capacity. In the rating of a regulator, the first figure signifies the number of poles with which the regulator is wound, the second figure denotes the k.w. capacity and the third the frequency. The k.w. capacity of any regulator is equal to the normal line current to be regulated times the maximum boost of the regulator and as the lower is equal to the boost, the total range is equal to twice the k.w. capacity. In the single-phase regulator the maximum boost or lower is equal to the capacity of the regulator in watts, divided by the secondary current. In the two-phase it would be one-half of that amount and in the three-phase type the boost or lower across the lines is equal to the regulator capacity in watts multiplied by .58 and divided by the secondary current.

The type of foundation depends upon the type of regulator to be installed. If it is an air cooled, it should be placed like a transformer over an air chamber that is perfectly air tight, so that all the air will be forced through the regulator. If a water cooled type, it is good practice to have it raised a little above the floor, so that the oil can be easily drawn off, if it ever becomes necessary, but in any type the supporting foundation should be very solid and well able to withstand the weight of the regulator.

It should be the operator's duty to keep the different parts of the regulator that require it well oiled, such as the top bearing of the regulator shaft, bottom bearing of regulator shaft, worm gear, segment and worm, motor and motor shaft bearings on the extension arm, motor worm gear and worm, shaft bearing supporting the hand wheel.

Special.

To cut the polyphase regulator out of service it is necessary to open the feeder circuit and disconnect the secondaries, but the single-phase regulator may be cut out of service by placing the rotor on the no-boost and no-buck or neutral position and then, by using a jumper, the main series line may be short-circuited across the regulator and the shunt circuit opened without any danger. If the operator has never done this it is better that he should open the circuit by means of the main switch and then disconnect the regulator.

A caution is always given with all regulators to never connect disconnecting switches in the primary side of the circuit, because if current was flowing in the secondary and switches were opened, the high voltage induced in the winding would probably damage the insulation of the regulator. For this same reason a standard rule is: Never use fuses in the primary circuit. The effect of opening the primary circuit when there is current flowing in the secondary is the same as opening the main field switch of a synchronous motor that might be starting from a compensator. The voltage induced into the field windings is very high and any opening or closing of switches at that time is always liable to cause serious damage to the machine, as well as to severely burn the operator doing the switching.

All operators when entering upon their first duties should keep in mind the several different complications that may arise by throwing switches at the wrong time. A few switching operations that should never be made are classified as:

1. Opening or closing switches on synchronous motor fields when starting from compensators.
2. Opening an induction primary circuit with current flowing in secondary circuit.
3. Opening secondary of current transformers.
4. Opening field circuit of direct-current generators when excited by main circuit, unless opened through resistance.
5. Opening field circuit of direct-current motors when running.

Voltage Compensators.

In large central stations it is most desirable to be able to know what the voltage is at the center of distribution. In order to accomplish this the voltage compensator has been devised, which, when once adjusted, will compensate for the line ohmic and inductive drop. The voltmeter will then register the exact voltage that is being maintained at the point of distribution at any load.

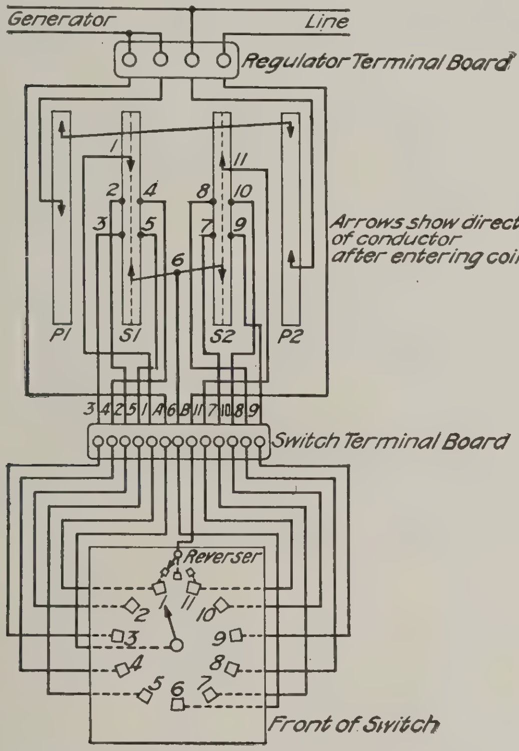

Fig. 42—Diagram of Connections for a Hand Operated Step-by-Step Feeder Voltage Regulator.

The compensator consists of three parts—a current transformer, a variable resistance and a variable reactance. The secondary of the transformer is connected in series with the resistance and reactance, and the primary is connected to the secondary of an external current transformer. Both the resistance and reactance coils are wound so that any portion of the coils can be cut in with the voltmeter circuit by means of two small dial switches, which give combined variation of about 15 to 20 volts. The connections of the voltmeter, as used with the compensator, are shown in Fig. 40. The voltmeter, instead of being connected directly across the terminals of the shunt transformer, is connected in series with a portion of the resistance and reactance of the compensator, and the combined drop across these is made equal to that of the line, so that the voltmeter indicates the voltage at the distributing point, instead of at the station.

If the amount of resistance and reactance is properly adjusted, the local circuit through the voltmeter will exactly correspond to that of the external circuit to which the compensator is connected and any change in the main circuit current or voltage will produce a like change in the local circuit. The adjustments must be made by means of the small dial switches X and R, which are set to a position that has a corresponding value to the ohmic and inductive drop of the feeder to which the compensator is connected. If this cannot be figured accurately, a good way of making the initial setting of the compensator is to have one person go to the point of distribution with a voltmeter and take readings at full load and have the station operator set the station voltmeter to a like reading by means of the dial switch.

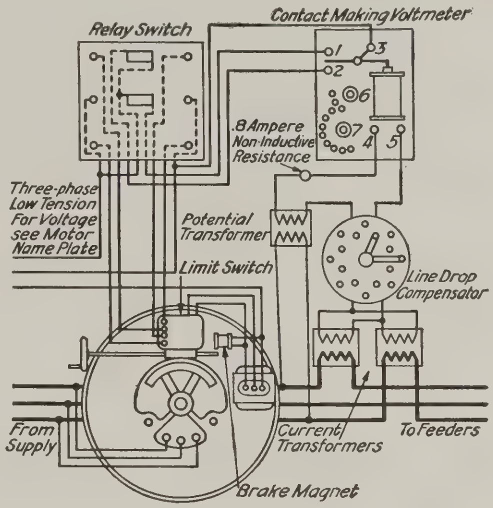

Fig. 43—Wiring Diagram for a Three-Phase Feeder Voltage Regulator Connected to Compensate for Line Losses

Thus far what has been said about the compensator has had reference to single-phase circuits, but the compensator can be arranged to compensate the voltage for a two or three-phase circuit by using two current transformers in the main lines and connecting the secondaries in parallel with the primaries of the compensating current transformer. A connection of this kind, as used on a three-phase circuit, is shown in Fig. 43.

Increase in Lifting Capacities of Magnets.

Since the feat of salvaging the boat load of barbed wire and nails from the muddy bed of the Mississippi River accomplished by Cutler-Hammer magnets in 1907, no important change has occurred in lifting magnet design. The Cutler-Hammer Clutch Co., of Milwaukee, is now, however, announcing a new series of magnets of the same rugged and watertight construction, but having lifting capacities ranging from 20 to 50 per cent greater than before. These increases have been made possible by the perfection of new insulation for the magnet windings. The lifting capacity, for instance, of the 62-inch magnet as given up to the present was about 2,600 to 3,000 lb., but for the new "High Duty" magnets, is increased to 4,000 and over.

Alternating Currents

Williard Doud *

Article No. 10

Rotary Converters

Conditions are often encountered where it is desirable to transmit alternating current a considerable distance and then distribute direct current for the operation of motors, lighting, etc. Where such conditions prevail it might be assumed that the best arrangement would be to operate a direct current generator by an alternating current motor. While this arrangement is sometimes used there is another method available which is more efficient and combines in a single unit of smaller size and cost a means of converting alternating into direct current. Such a machine is called a rotary converter and since its use is very extensive, some of its underlying principles will be discussed in this article.

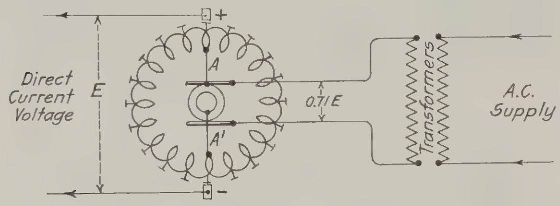

Fig. 1. Schematic Diagram of Connections for a Single-Phase Rotary.

In the earlier articles of this series an explanation was made, by means of diagrams and descriptions, of the difference between alternating and direct current generators of the simpler forms. It was pointed out that the current flowing in a generating coil of either an alternating or direct current generator was similar in character and that in the direct current generator the alternating direction of the current was changed to a flow in one direction by the use of a commutator. Briefly stated, the rotary converter is a direct current generator, in which taps are led out to collector rings from certain generating coils. The collector rings are usually placed on the opposite end of the armature shaft from the commutator, and the number required varies with the character of alternating current used.

The connection details for single-phase, two-phase, three-phase and six-phase rotary converters are shown in Figs. 1 to 4, inclusive. A perusal of the diagrams will show that the armature is tapped at two points and that leads are brought out to two collector rings for a single-phase rotary, a two-phase rotary is tapped at four points, with leads brought out to four collector rings, a six-phase rotary is tapped at six points and connections brought out to six collector rings, and for a three-phase rotary, which is the most commonly used, the armature is tapped at three points and leads are brought out to three collector rings.

It will be noted that there is a definite relation between the alternating and direct current voltages. To obtain this relative it will be evident that it is always necessary to install transformers to be used in connection with rotary converters. With a three-phase rotary the alternating current voltage is 61 per cent of the desired current voltage, while for single, two or six-phase rotaries, the alternating current voltage is 71 per cent of the direct current voltage.

In studying the diagrams it will be apparent to the reader why single, two and three-phase converters are used. The reason for using a six-phase converter, however, may not be so clear and it might be advisable to explain why it is sometimes preferred.

The following table, taken from the "Standard Handbook for Electrical Engineers," page 646, shows that with a reversed number of phases the armature losses in a six-phase rotary converter are much less than in a single-phase machine of the same type.

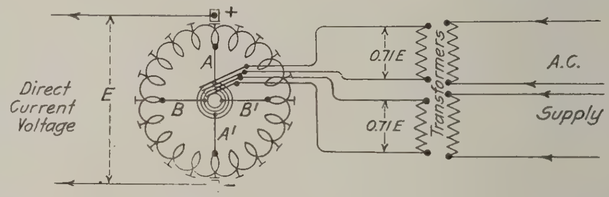

Fig. 2. Schematic Diagram of Connections for a Two-Phase Rotary.

	Relative armature loss in complete winding.				
No. of Collector Rings	P. F. 100 %	P. F. 98.5 %	P. F. 94 %	P. F. 86.6 %	P. F. 76.6 %
2	1.451	1.522	1.734	2.160	2.940
3	0.587	0.627	0.733	1.005	1.468
4	0.391	0.426	0.532	0.746	1.137
6	0.274	0.304	0.400	0.589	0.935
12	0.209	0.236	0.326	0.500	0.824

This table also shows the desirability of operating rotary converters on lines whose operating power·factors approach 100 per cent.

There are some very important characteristics of the rotary converters which should be understood by the reader. These include the action which takes place in the armature of the rotary during the process of converting alternating into direct current, and the control of voltage. Perhaps the most important difference between the rotary converter and the motor generator set is the fact that the former does not have the possible current and voltage regulation or control possessed by the latter. The diagram of connections for a single-phase rotary represents an armature in which connections are made to two of the generating coils diametrically opposite, leads being brought out from these connections to two collector rings. With such an arrangement it is evident that when the armature is operated in a properly excited field an alternating voltage will be produced at the rings. This is true because the two halves of the ring are in parallel and, when they revolve, are filled with lines of force which alternates in direction. If the rings are connected together by an outside circuit an alternating voltage will be induced. It is apparent that the operation of the machine as a direct current generator is not affected. The frequency of the alternating current would depend on the speed of the machine and the number of poles. With a single-phase, two-pole machine, the cycles per minute would be equal to the number of revolutions.

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*Consulting Engineer, Chicago, Ill.

The alternating voltage obtained depends on the speed of the armature and the strength of the field. As the speed increases with a decrease in field strength and *vice versa,* the same as a direct current motor, the alternating current voltage obtained from the rings can not depend on the field strength entirely.

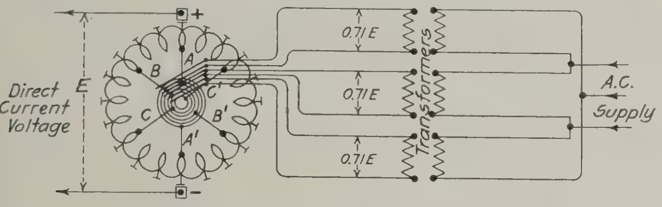


Fig. 3. Schematic Diagram of Connections for a Six-Phase Rotary.

If the machine was connected to an alternating current circuit which had the same frequency and voltage it could be made to deliver power to the outside circuit. Then if the direct current supply was removed the machine would continue to run as a synchronous motor and current would flow in the armature coils in such a direction as to produce rotation under the influence of the magnetic field. Considering any one conductor of the armature as receiving current in such a way as to cause it to rotate in the proper direction, synchronous rotation will cause the coil to move through the field, so that when the current reverses it will be in its correct location under the next pole. This is equivalent to a direct current winding revolving in an excited field and a commutator is provided, the machine is capable of producing direct current. The same reasoning will apply if the correct number of collector rings are used.

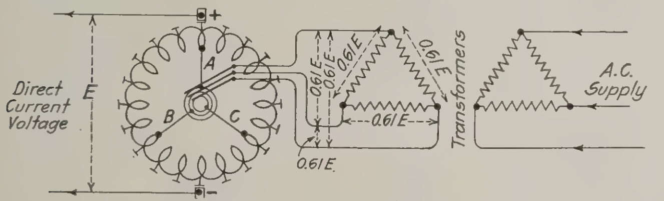


Fig. 4. Schematic Diagram of Connections for a Three-Phase Rotary.

The alternating current voltage at the collector rings of a rotary converter always bears a fixed ratio to the direct current voltage at the commutator. Varying the field strength has no appreciable effect on the voltage. The reason for this is that the ratios of alternating and direct current voltages of a rotary converter are so fixed that it will continue to operate when once started—receiving power from an alternating current source and delivering direct current, without any field.

Rotary converters are provided with field coils in all cases, however, as through their use it is possible to produce a regulation of voltage in the direct current end. This effect is produced by varying the strength of the fields, which is only possible under certain conditions in the alternating current circuit, and not due to the strength of the field itself. To vary the voltage, reactance coils are placed in the alternating current supply circuit. An increase of field strength causes a leading current in a rotary converter, which compensates for the lagging effect of the reactance coils, and thus eliminates a certain amount of the inductive voltage drop. Under such conditions the alternating voltage at the collector rings rises and causes a corresponding increase in the direct current voltage.

When the alternating current circuit to a rotary converter is equipped with proper reactance coils, the machine may be compounded and will operate like a compound would direct current generator.

Hydraulic Analogy.

The hydraulic analogy used in the earlier articles of this series to assist in explaining the action of direct and alternating current generators may be of some value to the reader in his study of this subject.

The action of a rotary converter is shown by a hydraulic analogy in Fig. 5. The figure is the same as that shown in the February, 1915, issue of the *Railway Electrical Engineer,* to illustrate the action of a direct current generator, except for the addition of one pipe leading to an external source from each end of the cylinder.

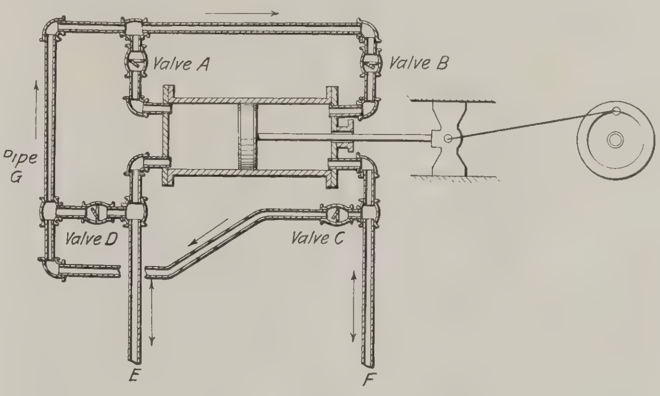


Fig. 5. Hydraulic Analogy of a Rotary Converter.

When a fluid under a reversing or alternating pressure is brought into the cylinder through pipes *E* and *F* the pressure of the fluid after it reaches the cylinder will be changed from the alternating to direct. In one direction when fluid flows in at *E* the piston will be forced from left to right, valves *B* and *D* will close and the fluid in front of the piston will flow through pipe *G* in the direction indicated by the arrow. When the end of the stroke is reached and movement of the piston started in the opposite direction by the pressure of the fluid entering pipe *F*, valves *A* and *C* will close and the movement of the fluid in pipe *G* will be the same as before. By a repetition of this process the alternating pressure of the fluid, flowing into the cylinder, will be changed so as to flow in one direction. In this illustration the piston does little more than open and close the valves *A*, *B*, *C* and *D* and the capacity of the cylinder is supposed to be very small compared with the total amount of fluid flowing. Similar conditions exist in a rotary converter, the alternating current from an outside source flowing through the armature is changed, by the commutator, into direct current. It must be noted that the piston must move back and forth in step or synchronism with the alternating current reversals. In the rotary converter the armature runs in synchronism with the alternating current supply.

To reverse the conditions of operation as outlined above, if direct current is admitted to the cylinder by the proper valves, alternating current will be delivered through the pipes *E* and *F*. The same results may be obtained from a rotary conveter which can be operated from a direct current supply to produce alternating current.

It will be evident that if the outlet valves are partially closed there may be considerable mechanical work performed on the piston in moving it back and forth. This pressure transmitted through the piston rod, crosshead, connecting rod and crank, to a shaft is capable of performing outside mechanical work. This being the case it may be stated that a rotary converter fitted with the necessary devices may be used for the following purposes.

As a synchronous motor to perform mechanical work;

As a rotary converter without performing mechanical work;

As a combination rotary converter and electric motor; and

As a rotary converter, converting alternating current into direct current, or *vice versa.*

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 48

Consolidated Type "L" Equipment

Replacement of Parts

Pole Changer Switch

If the contacts of the pole changer switch become burned the clips should be changed, but be extremely careful to keep the clips properly lined up so that they will make good contacts at all points on the blades and prevent future reoccurrence of the trouble.

Generator Fields

Fig. 245 shows the generator field frame from the commutator end with the brush holder housing removed. All leads come out of the field coils at the commutator end and connections are made at this point. It will be noted that the field coils are lettered a, b, c, d, as shown in Fig. 245, so that when applied and connected up, they will produce correct polarity. The field coils are provided with a stamped brass number and letter, the number indicating the voltage and the letter indicating the field position as shown in Fig. 245.

The field coil is held in place by the pole shoe, so in order to change a field coil it is first necessary to remove the pole shoe. This is done by removing the two bolts passing through the generator frame. In replacing the shoe the head of the cap screw should be forced into the groove on the yoke with a cape chisel in order to securely lock it.

Auto Switch

If trouble develops in an auto switch the whole switch should be removed from the panel and a new switch applied. This can be done by simply disconnecting the switch leads and removing the two nuts of the frame bolts.

The replacing of a carbon or copper brush has been covered under "Setting the Automatic Switch."

The Generator Regulator

The regulator complete can be easily removed from the front of the panel by simply opening all the coil connections and removing the two nuts at the right and one nut at the left side of the regulator. The bolts remain on the board.

In case, however, it becomes necessary to remove either the potential or the series coil of the regulator proceed as follows: Unhook the flat spring, *A,* Fig. 242, and remove the pin which passes through the stem of the solenoid plunger. Be very careful not to damage the rocking contact; it will be safer to leave it in its position on top of the commutator.

Next remove the dash pot by removing the two cap screws which hold it at the bottom. This allows the dash pot, piston and plunger of the solenoid to be removed. Don't remove the piston from the dash pot, for both the piston and dash pot are made of graphite and might easily get injured. Don't allow any dirt to get into the dash pot, for this will cause it to stick and give trouble in service. These dash pots are not interchangeable; a new piston requires a new dash pot and vice versa. The potential coil, which is located inside of the series coil, can be removed by first removing the magnetic stop at the top of the coil with its clamping screw, and the series coil can be removed by loosening the clamping screws at the top and bottom of the coil frame.

In reassembling, set in the series coil first, but don't tighten the connecting nuts. Insert the potential coil into the series coil from the bottom, but be careful not to scrape the winding against the edge of the brass tubing on which the series coil is wound, as this is liable to break the fine wire of the potential coil. Then insert the bottom binding screw in front of the potential coil, but don't tighten. Then replace the magnetic stop at the bottom of the coil and clamp with the screw.

The dash pot, piston and plunger complete should then be inserted from below, but be sure to have the bi-pass screw of the dash pot at the front. Tighten the dash pot by means of the supporting screws at each side evenly until tight. This allows the potential coil to rest on top of the dash pot and lines it up properly. The screws at the front and top can then be tightened so as to hold the potential and the series coils solid. After reconnecting the leads properly and inserting the pin connecting the rocker to the plunger stem, the rocker is ready to operate.

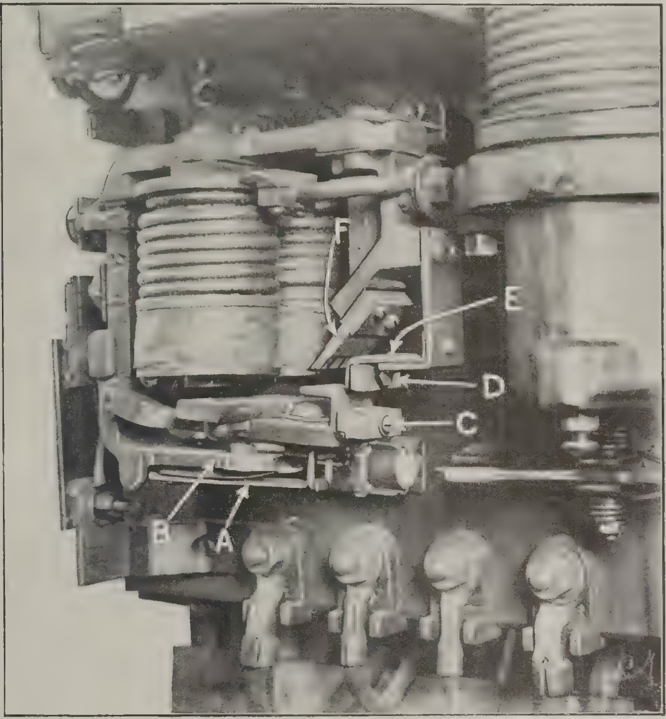


Fig. 246. Detail View of the Automatic Switch. "A," Flat Main Spring, Which Bears Against the Cam Immediately Above It and Mounted on the Frame "B"; "C," Movable Carbon Brush, Which Makes Contact on the Carbon "D"; "E," Copper Gauze, Which Carries the Current and Protects Steel Spring Supporting Carbon "D"; "F," Laminated Copper Main Brush.

The Rocking Contact Shoe

In case it becomes necessary to replace one or both of the laminated brushes of rocking contact, remove entire contact shoe, being careful to hold the solenoid plunger from dropping by re-inserting pin; after cleaning commutator apply contact shoe. Replacing contacts to shoes should be done at the bench. Removal of the two nuts holding the wedge-shaped retainer permits the laminations to be taken off. Their replacement is a simple matter, but care should be taken to tighten all nuts and screws. The commutator rarely gives any trouble whatever, but if this should occur the entire rheostat should be replaced and the damaged part sent back to the factory for repair. In replacing contacts always retain the same arm on the regulator; change the laminated contacts only.

Lamp Regulator

The lamp regulator may be taken apart in a manner very similar to that of the field regulator, as its construction, except for size and form, is very similar.

Operation of the Ampere-Hour Meter

The ampere-hour meter records both charge and discharge of the battery, the main dial hand revolving in a clock-wise direction on discharge and the reverse direction on charge. The variable resistor feature of the meter automatically provides 25 per cent. overcharge and when the large dial hand gets back to zero it indicates that the battery is in a fully charged condition and closes a contact at the zero point, which short circuits the resistance unit R1. This allows the overcharge switch to operate and the equipment then floats at 36 volts. It will be noted, however, that unless the battery voltage is up to a predetermined point, usually 40 volts, the overcharge switch cannot operate and the battery will continue to charge. In this way the combination of the switch adjustment with the ampere-hour meter compensates for irregularities in ampere-hour efficiency of the battery and keeps the meter "in step" with the state of charge. At the same time the generator output always varies in accordance with the number of lamps turned on.

In case of open battery circuit, the overcharge switch will operate at 50 volts, even though the ampere-hour meter does not indicate full charge. The system will then operate with constant potential control of the potential coil, and operate so long as the generator is up to speed, even though the battery be disconnected entirely.

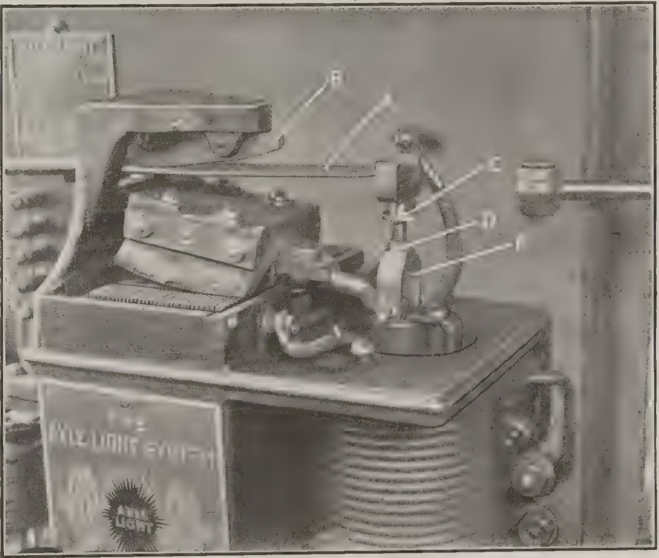


Fig. 247. Showing Detail Parts of the Generator Regulator. "A," Main Spring, Which Bears Against Cam "B"; "C," Adjusting Cap Screw; "D," Lock Nut; "E," Rocking Contact.

It will be noted that there is a differential coil added to the overcharged switch, this being indicated across the lamp circuit, so that so long as any lamps are lighted, even though the meter indicates full state of charge, the overcharge switch cannot be closed and discontinue charging. In other words, practical experience seems to show that some of the destructive overcharging has occurred during the daylight runs and the Consolidated Company has considered that an overcharge at night would be another precaution in ensuring that the storage battery be kept up to the full state of charge and exactly in step with the meter.

With this differential coil operating at night, and with an occasional open battery the overcharged switch will operate at 57 volts instead of at 50 volts in the daytime.

Maintenance of the Lamp Regulator

It will be noted that grease is applied to the contacts of the lamp regulator and this has a two-fold purpose. It prevents dust and dirt from getting on the metallic surface of the commutator and at the same time it prevents the oxidization of the metallic surfaces. Inasmuch as the grease completely excludes the air from the metallic surfaces, no oxidization can take place, so that even though there may be a slight arcing, the metallic surfaces will remain bright so that the brush will always make good contact on the commutator. Contrary to what might be supposed, this grease is not intended in any way as a lubricant, but merely as a protection; therefore, there must be sufficient grease to form a layer of at least 1/8 in. over the surface of the commutator, and this must be sufficiently plastic to flow together as the contact rocks and yet at the same time must not be so soft as to run off the commutator.

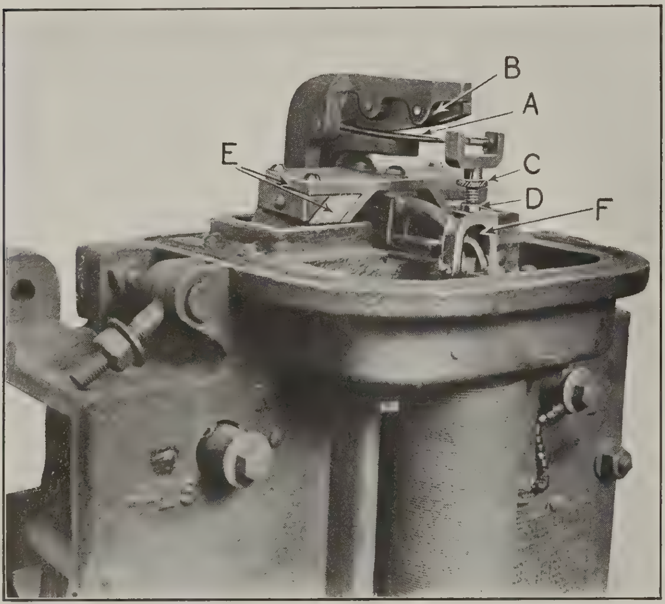


Fig. 248. "A," Main Spring, Which Bears Against Cam "B"; "C," Adjusting Cap Screw; "D," Lock Nut; "E," Laminated Copper Rocking Contact; "F," Saddle Connecting the Stem with Main Spring.

The standard ball bearing grease only should be used for this purpose. This should be replaced about once in six months; in fact, when the ball bearings of the generator are cleaned and regreased the commutator of the lamp regulator should also be cleaned and regreased.

Adjustment of the Lamp Regulator

It will be noted that the flat spring *A* comes to a "no tension" position every time the solenoid plunger drops sufficiently to permit lever to rest on the frame. It is a well-known principle in springs that if a spring is allowed to come to rest occasionally it will retain its original characteristics longer than a spring which is continually under tension or compression. Therefore, the spring of this regulator should not get out of adjustment due to spring fatigue, which ordinarily happens.

In case the flat spring *A* is accidentally injured or lost, a new spring should be secured from the Consolidated Company.

Never try to make up a copper, bronze or a brass spring, for this would not have the same spring characteristics for which the regulator is designed, and would not operate satisfactorily.

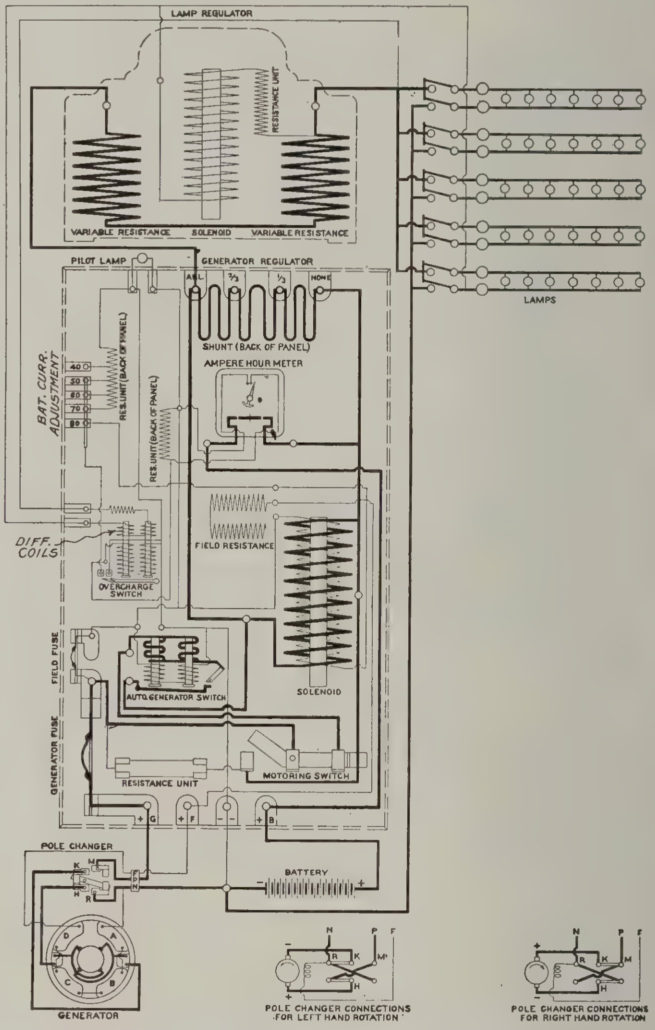


Fig. 249. Diagram of Connections of the Type "L" Consolidated Equipment, Showing the Relative Positions of Parts.

In case the regulator is out of adjustment but the spring apparently is in no way injured, the adjustment can be corrected by loosening the lock nut *B* (Fig. 248), and turning the thumbscrew *C* on the threaded stud in the link between the flat balancing spring and the stem of the plunger. Lowering the screw one turn lowers the voltage one volt. This weakens the pressure on the spring so that a lower voltage will rock the contact shoe to the same degree as formerly. If it is necessary to raise the regulator setting, turn the stud to the right, one turn rise of the thumbscrew being equivalent to one volt rise. After making the adjustment always securely tighten the lock nut.

Setting the Automatic Switch

This automatic switch should be set to close at 35 volts. In case it gets out of adjustment, however, it is a simple matter to remove the entire automatic switch and replace it with a spare switch. This can be done by simply loosening the coil connections and unscrewing the two nuts which hold the frame to the handle. Never adjust an automatic switch on the road.

It will be noticed that this automatic switch has a flat spring *A,* which bears against a curved cam surface very much the same as does the field or lamp regulator spring. This provides that the automatic switch will rise slowly as the generator voltage builds up. In opening, the switch also moves gradually, breaking the copper contact of the switch about as soon as the battery current begins to flow in a reverse direction to the generator so that there is very little, if any, arcing on the copper brushes. In closing the switch, the current first passes through the carbon contacts, and it will be noticed that a strip of copper gauze carries the main current as it leaves the spring supported top carbon contact and thus protects the spring supporting the upper carbon from heating and losing its temper.

In case the auto switch gets out of adjustment, this may be due to either improper position of the copper or carbon brushes or to the main spring *A,* Fig. 246, having been bent.

In order to adjust the switch, pull the main fuse so that the switch can be closed by hand without danger of short circuiting the battery through the dead armature of the generator. Then set the copper brush so that it makes a good working contact, and so that the heel of the brush touches solid. The carbon should then be adjusted by hand so that they come together parallel, and so that there is a space of three-sixty-fourths of an inch between the copper brush contacts when the carbons first touch.

In case the switch is found to close improperly after the main spring has been replaced, the trouble is evidently either in the lifting coil or the main spring. If the main spring has been seriously injured, it should be replaced with a new one obtained from the manufacturer. Never use a piece of ordinary steel, bronze or brass, as this will probably not have the same spring characteristics as the original spring and will not work satisfactorily.

Adjustment of Battery Charge

In order to vary the amount of charging current given the battery it is simply necessary to shift the jumper wire at the upper left-hand corner of the panel as shown in Fig. 249. Moving this jumper up to a higher contact short circuits segments of the resistance in series with the potential coil of the generator regulator solenoid. This allows an increase in current flowing through the potential coil and the ampere turns generated by this increased flow of current replaces ampere turns of a similar amount in the series coil. This means that the current flowing through the series coil will then be reduced. The contact bars are labelled 40, 50, 60, 70, 80, indicating amperes battery charge. They, however, are approximate and vary with the voltage of the generator.

If, after throwing on all lamp and fan circuits, it is found that the total load exceeds the total capacity of the generator, the total generator output may be reduced by shifting the contact to the shunt of the generator regulator located at the top of the panel.

With the lamp regulator lead connecting at the "all" point, the generator picks up all of the lamp load without varying the battery current. With the lead connected to the "2/3" point, it picks up two-thirds of the lamp load; connected to the "1/3" position it picks up one-third of the lamp load, meanwhile the battery current decreasing by two-thirds of the lamp load.

The Railroad Electricians' Club

January Meeting New York Car Lighting Association

H. D. Rohman, chief electrical engineer of the Franklin Railway Supply Company, addressed the club on the subject of the "Stone" axle lighting system. Mr. Rohman stated that although various parts had been changed somewhat, the equipment to-day operates on identically the same principles as it did twenty-four years ago, when first installed. Mr. Rohman called attention to the fact that although all of the many types of axle lighting systems may seem to be somewhat similar in that they all have a generator and a storage battery, there is a vast difference in the principles of controlling the operation of the generator in compensating for the varying train speeds.

He stated, however, that all of the axle generator systems may be divided into two classes, (1) variable speed systems and (2) constant speed systems. The variable speed systems include practically all of the other types of axle generator equipments and in these the belt tension is raised to a high initial value so as to provide that there will be no slipping whatsoever. The armature speed will then vary directly with the speed of the train. With the constant speed equipment, such as the "Stone" system, the belt is allowed to slip after the train speed exceeds a certain value, usually about twenty miles per hour, so that even though the train speed be two or three times this value the running speed of the armature will not be above normal, equivalent to the twenty miles per hour operation.

Mr. Rohman pointed out that in designing a car lighting equipment it is of utmost importance that the designer bear in mind the characteristics of secondary batteries, and this has been the starting point in the design of the Stone equipment. The generator should be so designed that it will re-charge the battery in the shortest period, and yet at such a rate it will not be injurious to the battery, and in order to keep down the temperature of the cells it is imperative to provide for a charging current, which decreases as the battery nears the fully charged state. With the Stone equipment the natural taper charge is augmented by the peculiar electrical connections of the two halves of the batteries relative to the generator and by the method of lamp regulation.

The maximum generator speed is approximately 800 r.p.m. and the pressure of the generator pulley upon the belt is caused by the generator being hung approximately two inches out of plumb. At the higher train speeds the generator tends to develop a higher voltage and to cause a higher battery charging current to flow. Such an increase in generated power, however, necessarily requires more power from the belt, which it cannot furnish in this case, because, above a certain belt pull, the generator will be drawn a little farther out of plumb, causing the belt to slip.

The output of the machine is adjusted by tightening the belt and pulling the generator farther out of plumb. Mr. Rohman described an ingenious device for estimating the maximum output of the machine. This device consists simply of a spirit level mounted on top of the generator. The bubble of this level moves along a scale, graduated in amperes, as the machine is swung toward the driving pulley by increasing the belt pull.

Mr. Rohman gave a full description of the equipment, but as this will be completely described in the next issue of the *Railway Electrical Engineer* under the A B C Car Lighting Section, we will not go into details at this time.

Mr. Rohman, however, pointed out the excellent regulation of lamp voltage which is obtained by dividing the battery into two units. One battery acts as a lamp voltage stabilizer, while the other battery is being charged by the generator. When the car is at rest, at the station, the lamp current is taken from both batteries in parallel, but when the train gets up to speed, after leaving this stop, the freshly charged battery acts as a stabilizer and its mate is given a charge.

Questions

Effect of Open Battery Circuit.

A. J. Pettyman asked what would result from an open-circuit in the battery which was being charged. Mr. Rohman stated that there would, of course, be a rise in voltage, but this would not be appreciable because the stabilizing battery would then receive a charge and protect the lamps from excessive current. Moreover, since the generator operates on the special principle of constant watts output instead of constant current output, an increase in generator voltage will mean a decrease in generator current. The inherent regulation of the system would also materially assist in such a case of trouble.

Changing from Lead to Edison Batteries.

In reply to a question as to what was necessary in changing from lead batteries to the Edison batteries, Mr. Rohman stated that this would simply require a slightly higher constant resistance between the stabilizing and charging battery.

Belt Tension.

In reply to a question as to what belt tension is required, Mr. Rohman stated that this should be only enough to pull the generator out of plumb to such an angle as would cause the bubble of the spirit level to indicate at the proper point on the ampere scale.

Effect of Sulphated Battery.

In reply to a question as to how the "Stone" system will take care of a sulphated battery, Mr. Rohman stated that this will be done properly, inasmuch as the battery will be given a sufficient charge, even though it may require an abnormally high voltage to break down the sulphate. He pointed out, however, that at this high voltage the charging current will be automatically reduced, which is desirable in case of a sulphated battery.

Arc of Belt Contact.

In reply to a question as to what the arc of belt contact on the generator pulley was, Mr. Rohman stated that this would be approximately 170 degrees, inasmuch as a 17-in. axle pulley and a 5½-in. armature pulley is used with about 5 ft. spacing between the centers.

Life of Armature Pulley.

In reply to a question as to what life can be obtained from armature pulleys, Mr. Rohman answered that with a steel stitched cotton belt an average of approximately two years' service is obtained from a generator pulley.

Removal of the Armature.

In reply to this question, Mr. Rohman stated that by removing four tap screws, the entire armature with both ball bearings can be drawn out and a spare armature, with bearings and head, applied in a very short time, usually about one minute. He stated that the armature, with its housing and bearings, weighed approximately 80 lb.

Rule of Setting Generator Output.

In reply to this question, Mr. Rohman stated that they had made it a practice generally to set the output of the generator equal to the average load, lamp current plus one-third, but should be accurately determined by specific gravity reading.

Pulley Flanges.

Mr. Rohman stated that the armature pulley was 5½ in. wide and the axle pulley had a 10-in. face and both are supplied with 2-in. beveled flanges. The tapering of this flange being approximately 20 deg. from perpendicular, practical experience having proved that this is the most advantageous taper of the flange.

Voltage Control With Single Battery.

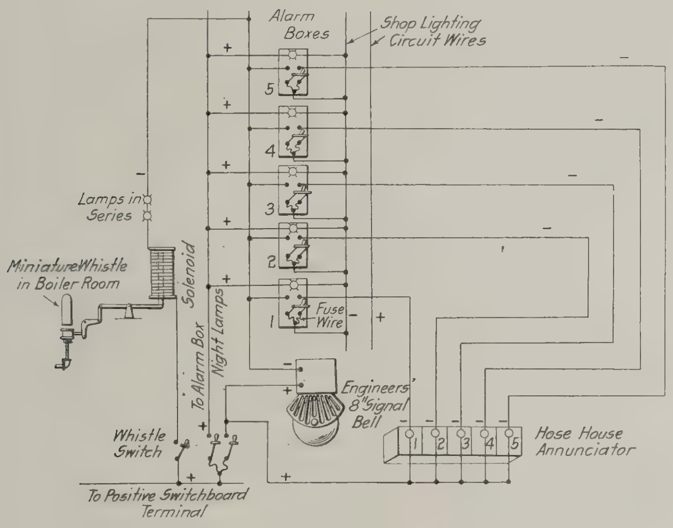
D. J. Cartwright, electrical engineer of the Lehigh Valley, asked what kind of regulation would be obtained with a single battery equipment on a car having two or more lamp circuits. Mr. Rohman stated that this should be satisfactory, provided that a proper lamp resistance was inserted in each individual lamp circuit.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

A Safety First Fire Alarm System

The following is a description of the fire alarm system which has been in operation at the shops of the Cincinnati, Hamilton & Dayton, at Lima, Ohio, for the past four years without a single failure. During this time it has been used nine times for actual fires and 206 times in fire drills. This system has been styled a "Safety First" system for the reason that only negative wires are used at the alarm boxes. As indicated in the accompanying sketch, the positive current is tapped from the power plant switchboard, and the nearest negative service lines at the alarm boxes are used to complete the circuit. Each alarm box is provided with a light, which is lighted at night, and a two-pole switch, the closing of which performs three functions. It rings an 8-in. 2,000-ohm gong in the power house, blows a whistle in the boiler room, and operates a lamp annunciator in the hose-house, showing the number of the alarm box from which the alarm was rung in. The engineer or fireman, whoever is nearest the shop whistle as soon as the alarm is sounded, sounds the whistle giving the signal for fire call. The men in the plant who are appointed to act as firemen, rush to the hose-house, ascertain from the annunciator the station from which the alarm was sounded, and pull the wheel cart, which contains 1,000 ft. of hose, to the water plug nearest that station.


Alarm Boxes
Shop Lighting Circuit Wires
Lamps in Series
Miniature Whistle in Boiler Room
Solenoid
To Alarm Box Night Lamps
Fuse Wire
Engineers' 8" Signal Bell
Hose House Annunciator
Whistle Switch
To Positive Switchboard Terminal
1
2
3
4
5
+
−

Wiring Diagram for Safety First Fire Alarm System.

Recently a test was made by the master mechanic to ascertain the time taken to respond to the alarm. It was found that 22 seconds after the close of the alarm switch the shop whistle sounded the fire alarm, and 2 min. 20 sec. after the close of the alarm switch a stream of water 40 ft. high was running from 150 ft. of hose. The firemen in this case had to run approximately 300 ft. to the hose-house and pull the hose cart to a water plug 100 ft. from the hose-house. This performance was believed to be highly satisfactory, especially in view of the fact that the men were not forewarned before the alarm was turned in.

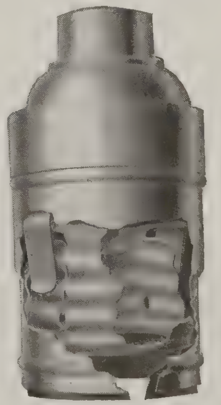
It will be noted that three leads are taken from the positive line at the switchboard, those making the connections with the bell and the solenoid which operates the boiler room whistle, being closed at all times, and the third, which closes the circuit to the night lamps at the alarm boxes being closed only at night. The solenoid and bell circuits being in parallel are operated from the same pole of the two-pole switch in the alarm box. The current used is 220 volts d. c., with 5 amphere snap switches in the alarm boxes, and 15 ampere switches in the power house. This system has the recommendation of the electrical and insurance inspectors.

J. O. Burris
Electrician C. H. & D. Ry., Lima, Ohio.

Lamp Grips on Bryant Sockets.

Considerable trouble and inconvenience has been experienced in the use of lamps in sockets when installed where subject to vibration. This is particularly true in factories using high candle-power lamps where heavy machinery is operated, and on steam and electric cars, steamboats, etc. Constant jarring and vibration cause lamps to unscrew or "back off" from the base contact so that the circuit is broken and often the lamp falls.

To overcome this difficulty, The Bryant Electric Company has developed a very effective "lamp grip." In this new form of socket, the threaded copper portion which receives the lamp is slotted on two diametrically opposite sides in such a manner as to provide two tongues which are flexible. Two flat steel springs are mounted in the porcelain base with the free ends so arranged as to bear on the outside of these copper tongues. This will be clearly understood from the illustration. Thus, without any external adjustment, or any other labor than the insertion of the lamp, sufficient tension is brought to bear upon the lamp base to prevent vibration from causing the contact to break even under the most severe conditions, such as those usually found in shops with line shafting.



This lamp grip feature can be supplied at a slight additional charge, in connection with practically all sockets of both the medium and mogul type manufactured by the above company.

Personal Mention

Henry Lee

Henry Lee, secretary and treasurer of the Simmons-Boardman Publishing Company, publishers of the *Railway Electrical Engineer,* has been elected a vice-president. Mr. Lee has spent his entire business career with the Railway Age Gazette and The Railway Age. He was born at Hamlet, Ill., on May 25, 1884, and was educated in the common schools at Hamlet, and the high school at Aledo, Ill. In 1905 he graduated from a business college in Chicago and on June 6 of that year joined the staff of The Railway Age as assistant to the business manager. In December, 1906, he was assigned to the news staff and in September of the following year became an associate editor and was transferred to New York. On the consolidation of the Railroad Gazette and The Railway Age as the Railway Age Gazette in June, 1908, he was transferred back to Chicago. In April, 1909, however, he returned to New York, was put in the business department and placed in charge of the advertising make-up desk. About November, 1909, he was given charge of writing advertising copy and thus founded the copy-service department of the publication. He was shortly afterwards made one of the paper's representatives in the trade, and in March, 1910, was made secretary. In February, 1911, he was also elected treasurer, becoming in June, 1912, a director. Mr. Lee has also taken an active part in the publishers' organizations devoted to technical and trade papers. In 1911-12 he was secretary and treasurer of the Federation of Trade Press Associations of the United States, and in January of this year was elected secretary of the New York Trade Press Association. As vice-president of the Simmons-Boardman Publishing Company he will also continue as treasurer of the company.

Eli R. Manor

Eli R. Manor was appointed chief electrician of the Northern Pacific Railway Company on December 15, 1915, with headquarters at St. Paul, Minn., vice K. R. Hare, who resigned on November 15, to take the position of associate editor of the *Railway Electrical Engineer.* Mr. Manor is a graduate of the College of Electrical Engineering, University of Wisconsin, class of 1909, and has been employed with the Northern Pacific since June, 1910, as dynamometer car expert.

New Books of Interest to Railway Electrical Engineers

Standard Handbook for Electrical Engineers. Prepared by a staff of specialists under the direction of Frank F. Fowle, Consulting Electrical Engineer, Editor in Chief. 1,984 pages, fully illustrated, 4 in. x 6⅝ in. Bound in leather. Published by the MacGraw Hill Book Co., Inc., 239 W. 39th St., New York. Price, $5.00.

The present edition of the standard handbook for electrical engineers embodies so many changes and additional matter that it is virtually a new book, retaining, however, the general features and scheme arrangement which has received extensive endorsement in this higher edition. As heretofore, the standard handbook is intended, primarily, as a reference book on practical information and data for practicing engineers. The authors have made a special effort to present as much information and data of a practical nature as space would permit, reducing descriptive matter to a reasonable minimum and relying on references to standard works for an extended dissertation on theory and highly special topics. By the studied use of bold faced type the real subject of each paragraph has been brought out in a prominent way.

Electrical Measurement and Meter Testing. By David Penn Moreton, Associate Professor of Electrical Engineering, Armour Institute of Technology, Chicago. 328 pages, 191 illustrations, 4 in. x 6½ in. Bound in cloth. Published by Frederick J. Drake & Co., Chicago. Price in lint cloth, $1.00, in full leather, red edges, gold stamping, $1.50.

This new practical meter book has been written by Professor Morton with the special object of making the subject matter clear and easy to grasp.

The fundamental theory is clearly presented, practical applications are shown, and numerous examples and their solutions are given. The illustrations, which are all carefully explained, form one of the most valuable features of the book. A copious index makes quick reference possible, and adds much to its usefulness.

The first five chapters are devoted to the treatment of the fundamental principles of electricity, because a clear understanding of these principles is necessary to everyone who desires to post himself on the application of practice.

The remaining eight chapters treat of the electrical measurement and the construction, operation, and the calibration of the instrument used in making such measurements.

The Electric Railway. By A. Morris Buck, Assistant Professor of Railway Electrical Engineering, University of Illinois. 376 pages, 192 illustration, 5¾ in. x 9 in. Bound in cloth. Published by MacGraw Hill Book Co., Inc., 239 W. 39th St., New York City. Price, $3.00.

This book has been written by Professor Buck to meet the need of an adequate text book for instruction of advanced students of railway electrical engineering. Although intended primarily as a text book, it is believed that this volume contains much matter of interest to the practicing engineer, since it purposes to give the underlying principles of electric railway design and operation.

Single-Phase Electric Railways. By Edwin Austin, on the Editorial Staff of "The Engineer." 294 pages, 346 illustrations. 8 in. x 11 in. Bound in cloth. Published by the D. Van Nostrand Co., 25 Park Place, New York. Price, $5.00.

This book is devoted to description of complete railways and portions of main line railways, electrified on the single-phase system. Most of the chapters appeared originally in the columns of "The Engineer." Its primary object is to show what has been done abroad and to put before engineers and others interested in railway electrification, details of overhead equipment, locomotives and motor coaches used on the English, Continental and American single-phase lines.

Wray's Manual of Car Lighting and the Pennsylvania Railroad School of Electricity. Edited by Edward Wray, Business Manager, Railway Electrical Engineer. 330 pages, fully illustrated, 9 in. x 12 in. Bound in cloth. Copies of this book may be obtained from the MacGraw Hill Book Co., Inc., 239 W. 39th St., New York. Price, $2.00.

This book has been compiled entirely from a series of lessons and articles published monthly in the Railway Electrical Engineer, including the following: (1) *42 lessons of the A. B. C. Car Lighting course,* covering three and one-half years' work, describing nearly every type of car lighting equipment ever used, numerous lessons on storage battery, principles of electricity, magnetism, etc. (2) *14 lessons of the Pennsylvania Railroad School of Electricity* (all that has been published by that road so far). (3) *20 lessons of the Railroad Electric Club.* In each lesson many practical problems on batteries, operation and maintenance of car lighting equipment, figuring wiring circuits, etc., were fully worked out and explained. This is one of the most valuable departments in the book. (4) *Practical Stunts,* as published in over 30 issues of the Railway Electrical Engineer. This department is maintained by the practical men on the job, and here you will find many valuable stunts which the other fellow has worked out, and which will help you in your own work. (5) *Prize Question Box,* as published in nearly 30 issues of the Railway Electrical Engineer. This is another department maintained by the readers, and a great many practical questions are asked and answered. (6) *Motor Section.* This series of lessons was started weekly for the shop electrician. Each month articles are published, one prepared by Mr. J. H. Wickman, General Foreman Electric Department, Illinois Central Railroad, giving the practical dope on A. C. Motor Windings, Armature Repairs, Testing, etc. The other series of articles on principles of alternating currents is prepared by Mr. Willard Doud, Consulting Engineer, who, personally, has had charge of many big shop installations. This book includes the 12 shop motor articles published so far and is very thoroughly indexed.

General News Section

Flood Lighting for Terminal Yards

Experiments in lighting terminal yards by the Flood lighting system are being made by the Pennsylvania at the Twelfth street coach yards in Chicago. Six 1,000-watt stereopticon mazda type C lamps with concentrated filaments are being used in a searchlight frame about 16 in. in diameter and 14 in. deep. Adjustable parabolic reflectors 12 in. in diameter are used, they being adjusted to give the proper flood of light at the proper distance. These are mounted on the top of the coal chute and other high buildings in the absence of suitable towers to support them. These lights are rated at 150,000 candle power at 1,500 ft. The length of the surface lighted by one unit is approximately 1,800 ft. long and 350 ft. wide when the lamp is mounted at a height of 65 ft. Although it has not been possible to locate these lights at the desired height at the present time they have given such results that the system is believed to be entirely practicable. The yard can be better lighted at a decrease in power consumption. At the present time the lights are used to illuminate the busiest leads and the yard men are highly enthusiastic with the results of the experiments and are strong advocates of this system of lighting. The lights are at such a height that they are well above the clouds of steam coming from the locomotives and are sufficiently powerful to penetrate through them.

Experiments are also being made with a 500-watt lamp mounted in a similar frame in the engine house, the light being placed on the wall between the pits. It also has proved satisfactory and by its use a material reduction is made in the amount of current required for suitable lighting. It is expected that a permanent installation will be made in the near future. The lamp fixtures are being furnished by the American Lighting Company, Chicago.

Patent Decision Favors U. S. Light & Heat Corporation.

The Circuit Court of Appeals for the Second District has just handed down a decision confirming the prior decision of Judge Hazel, of the United States District Court for the Western District of New York, holding the Thompson patent on the carbon disk regulator invalid. The Safety Car Heating & Lighting Company alleged that the carbon disk regulators manufactured and sold by the U. S. Light & Heat Corporation were infringements on this patent, but the decision holds that the latter company, through its predecessors, had used the carbon disk regulator prior to the Thompson patent and that the patent covered no additional features which were patentable, and was therefore invalid. The Safety Company moved for a rehearing before the Court of Appeals, but this rehearing was denied, so that the decision by the Court of last resort now stands in favor of the U. S. Light & Heat Corporation.

Some War Orders That Didn't Come Through.

Six hundred members of the Chicago Electric Club, Jovian League, witnessed the installation of officers at the annual meeting at the Hotel Sherman, January 7, and after dinner everybody enjoyed a rousing old poker.

The jest of the evening was a disguised member of the Royal Chinese family, alias a South Clarke street Chinaman dressed in evening clothes, who, it was stated, was here incognito to purchase electrical goods for the Chinese Government. It was explained by the toastmaster that he spoke no English. An interpreter would be available.

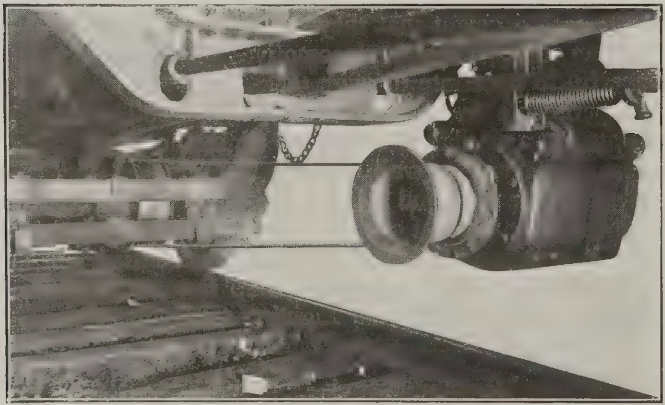
Fifty of the live wires among the Jovians quickly found cause for leaving the party to get in touch with their firms, having visions of a monster export order.

About that time the Celestine importation stood up and said, "I got to beat it back to the laundry."

George Hull Porter, manager of railway sales of the Western Electric Company, Chicago, was chairman of the entertainment committee—we might have known that had the Chinaman been the straight goods and with a bunch of orders to place he never would have gotten by George.

New Gould Body Hung Suspension.

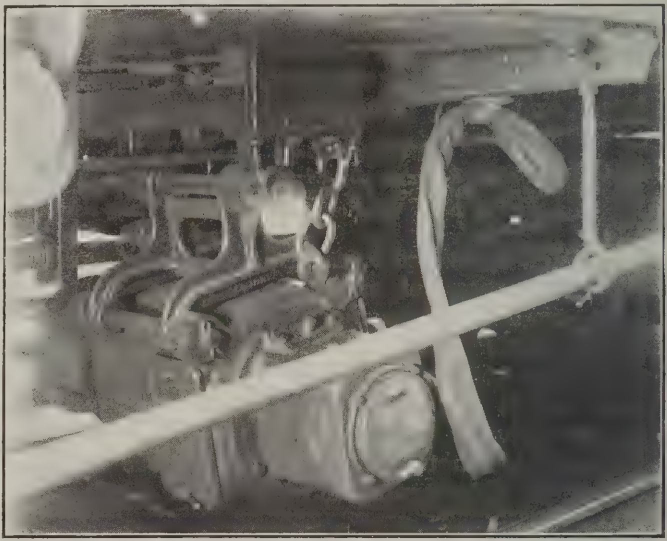
The accompanying illustrations show a standard Gould generator mounted on the car body, instead of the standard truck type suspension. The generator is inverted so that the four supporting lugs are at the top, instead of at the bottom, as in the truck mounted type. Two steel shafts are passed through the lugs and connect the generator to its supporting frame.



A Standard Gould Axle Generator Mounted On the Car Body by the New Type of Suspension.

This frame, as will be noticed from an examination of the illustrations, supports the generator from a single shaft and accordingly all wear comes on this one shaft. The supporting frame itself, however, is bushed so that wear at this point may be easily compensated for by removal of bushing and supporting shaft. Safety chains are provided, as will be noticed from the illustration.

The pole changer head of the generator is also inverted so as to make the pole changing mechanism operate correctly. The machine, itself, however, is simply a standard machine and no other alteration is necessary other than to provide for the special supporting steel castings and mountings on the car body. The magnet frame adapter casting and the yoke from which it suspends are the same for all types of Gould generators.



New Body Hung Suspension for Gould Standard Axle Generators.

Trade Publications

Electrical Apparatus.—One of the recent publications of the railway and lighting department of the Westinghouse Electric & Manufacturing Company is an illustrated booklet containing a paper presented before the Railway Club of Pittsburgh by E. M. Herr, entitled "Notes on Electric Power Development."

Conduit Chart.—National Metal Molding Company, manufacturers of electrical conduits and fittings, Pittsburgh, is distributing an attractive wall hanger, reproducing, in one-half actual size, conduit charts as adopted and recommended by the National Electrical Contractors' Association, showing sizes of conduit required by the National Electrical Code for carrying various sizes of conductors. This hanger is printed on linen-backed stock and will prove of convenience for reference in the offices of architects, engineers and electrical contractors.

Wiring Device Catalogue.—The Bryant Electric Company, of Bridgeport, Conn., has recently issued a complete publication devoted to Bryant-Perkins' wiring devices. A novel feature of this catalogue, which should prove most useful, is that each device listed is illustrated along the margin of the page and a red arrow runs from the descriptive matter of the device to the illustration showing it. Several pages at the back of the catalogue are devoted to instructive wiring diagrams and methods for calculating feeders.

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Work of the A. R. E. E. Committees

The work of the committees of the Association of Railway Electrical Engineers is being actively carried on in preparation for the annual convention of the association to be held in Chicago some time in the latter part of October.

Probably one of the most important pieces of work ever undertaken by any committee of this association is that of standardizing motors for shop traveling cranes. This committee has already held one meeting early in February, and two sub-committees, one on "Motor Ratings" and the other on "Dimensions" have held sub-committee meetings. The committee is endeavoring to standardize both on crane sizes and operating speed, these latter being necessary before any standardizing of motors can be undertaken.

As to motor standards, the committee expects to make recommendation as to motor sizes for various functions with certain crane sizes and operating speeds. In addition to this it expects to give a standard method of rating motors for traveling cranes and also to standardize overall outline, base templates, shafts and keyways.

The whole purpose of the committee is to increase the reliability of the shop traveling crane, making it possible, in case of motor troubles, to replace any crane motor with any other crane motor of proper size, instead of having to tie up the crane or limit its operation for two or three weeks until the defective motor can be replaced by one procured from the manufacturer. With a reasonable degree of standardization for crane motors it will then be possible, by carrying simply one spare motor of each of the sizes in use, to make immediate repairs to any crane. The many advantages in operating efficiency of such interchangeability of crane motors are at once evident.

The committee on Metal Conduit has become well organized during the winter and some very instructive and interesting service tests have been started in which the various brands and types of conduit are exposed to the most severe service conditions.

Rating of Incandescent Lamps

The steady improvement in the efficiency of incandescent lamps which began with the development of the gem, tantalum and tungsten lamps about eight years ago, has been the cause of changing from a candle power to a watt basis of rating the lamps, and at present there seems to be considerable discussion as to the advisability of making another change by adopting the mean spherical candle power rating as the basis for rating incandescent lamps in the future.

In this connection, however, it is interesting to note that the Illuminating Engineering Society, the American Institute of Electrical Engineers, and the Committee on Electrical Measurement and Standards of the National Electric Light Association have urged the adoption of the lumen basis for rating all illuminants in preference to either the wattage, the mean horizontal candle power or the mean spherical candle power basis. We sincerely hope that the Association of Railway Electrical Engineers will also go on record, at its next convention, as advocating the use of the lumen for rating illuminants in preference to recommending the mean spherical candle power.

The rating in mean spherical candle power tends to degrade the lamps as compared with the rating in mean horizontal candle power; that is, the nominal candle power of the lamp will be less if rated in mean spherical candle power. In other words, the mean horizontal candle power of a 25-watt lamp is 22.72 candle power, while the mean spherical candle power of the same lamp is only 18.4 candle power, the lower value of the mean spherical candle power being due to the fact that this basis takes into consideration the upward and downward intensities which are, of course, much less than the horizontal intensities, due to the filament construction. This objection is an important one from a commercial viewpoint because if a spherical basis is adopted the future lamps will apparently be operating at a lower efficiency by about 20 per cent. than at present.

The lumen is the correct and logical unit of a lamp output as it measures the total light flux, not merely an intensity in a certain direction. The lumen is intimately connected with the more common illumination units inasmuch as one lumen per square foot is equivalent to the illumination of one foot candle. Therefore, instead of being a new or mysterious unit, the lumen is one which illuminating engineers, from practical experience, have found to greatly facilitate the working out of illuminating problems. For instance, assuming that it is desired to provide an illumination of 2 foot candles in a room 10 ft. by 10 ft. The area of the room is 100 sq. ft., and it would then require 200 lumens of light flux to illuminate this area to an intensity of 2 foot candles. Assuming that the lighting unit with reflector directs only 50 per cent. of its total light on the working plane, it is very evident that a 400 lumen lamp would be required to give the desired illumination.

The lumen rating leads directly to a proper expression for lamp efficiency; namely, lumen per watt. Lumen per watt will always come out a number greater than one and hence it will be a more convenient unit to use than fractional parts of a watt per candle. The connection between the total lumens of a lamp of standard construction and its candle power is such that an approximate value of horizontal candle power may be obtained by dividing the number of lumens by ten, and further, the total lumens of a lamp and its mean spherical candle power are connected by the factor 4π; in other words, the total lumens of a lamp of 20 mean spherical candle power would be 20 times 12.5664 or 251 lumens.

Both candle power and watts are arbitrary units for designating the size of a lamp or for designating the amount of light which any lamp will give. In the same way it may be said that the lumen is also an arbitrary unit, but it happily has the important advantage of tying together the total light flux generated in the lamp with the illumination in foot candles produced on the working plane. This is because one lumen per square foot equals one foot candle. It is also true that it will be just as easy to adjust ourselves to the idea of specifying lamps in lumens as it was to specify them in watts, and, as it would be to specify them in mean spherical candle power; furthermore, during the process of becoming so adjusted to the new rating we would be comforted by the thought that no other change will ever be advocated, or suggested, because no other will ever be desirable or necessary.

If the basis of rating railway lamps is changed over to a mean spherical basis we will very likely in a few years find ourselves entirely without company and will feel the necessity of making another change to the lumen basis. The entire electrical industry is undoubtedly veering towards a general adoption of the lumen basis of rating lamps, and any adoption of the mean spherical candle power basis is therefore only a half-way measure which will lead eventually to still another change to the final and logical lumen rating.

Any change that is made will mean a period of educational work required to familiarize lamp users with the new rating. As the lumen rating will unquestionably be adopted some day, why not have it over with and eliminate the trouble connected with an unnecessary intermediate step? Why not go to the logical rating now?

We gladly open our columns to a discussion of this important subject and cordially invite you to send us your views.

Clean Lighting Fixtures

Railroad officials appreciate more than ever before the value of good lighting, not only from the advertising value of serving the public and providing more attractive stations and cars, but also from the dollars and cents point of view as well. This is evidenced by the areas about some of the prominent railroad terminals which are brilliantly illuminated and also by the fact that many railroads are now equipping their classification yards with an adequate lighting system.

Recognizing the need of, and installing a good lighting system, however, is only half the battle. In order to continue to receive the benefit of a good lighting system, the lighting fixtures must be kept clean.

There is nothing on a railroad that depreciates so rapidly as does the efficiency of the lighting system. The rapid collection of dust and smoke on the lighting fixtures causes the illumination to be reduced to about 50 per cent of its initial value in some locations within a week, and in the average station or shop it would reduce to about 50 per cent efficiency in one month.

All types of lamps and reflectors require cleaning, and reflectors which allow some of the light to show through the bowl, as in nearly all glass types, except mirrored reflectors, are more seriously affected by a collection of dirt on the outside of the reflector than are reflectors of the enameled steel type.

Every railroad should recognize the advisability of providing for the proper maintenance of its lighting systems, including the inspection and cleaning of reflectors and globes. This work should be included in the regular routine of shop maintenance and should be placed in the hands of the shop electrician or other special maintenance department. With the modern practice of mounting large candle power lamps overhead instead of placing small lamps near each machine, the importance of relieving the workman from the care of lighting fixtures is greater now than it was formerly.

The saving effected by systematically cleaning reflectors and lamp bulbs will more than pay for the small extra expense involved. The following example will serve to emphasize this point. Take a railroad which operates 5,000 150-watt lamps and assume that these lamps burn 8 hours out of every 24 and that the cost for current is two cents per k. w. h. The total cost of current per year then will be $37,560. It has been shown in numerous tests that a collection of dust and soot on reflectors and lamp bulbs will reduce the illumination by 50 per cent. This means that if the 5,000 reflectors and bulbs above mentioned are not cleaned half of the light from these lamps will be absorbed and wasted causing a direct loss of $18,780 per year, while on the other hand this amount will be saved if the reflectors and bulbs are systematically and regularly cleaned. The cost of cleaning will not amount to more than 3 cents a fixture a month or a total of $1,800 a year, which is only 9.6 per cent of the saving. In other words 1,040 per cent will be earned by the investment.

In addition to the saving in energy thus effected will be the saving in workmen's time which would be lost due to inadequate illumination if the reflectors and bulbs are not cleaned. Ordinarily the expenditure for lighting is about ½ of 1 per cent of the wages of the workmen employed, while to properly maintain that lighting system costs only about 1/30 of 1 per cent of the wages.

Chattering Wheel Slip in Electric Motive Power*

By G. M. Eaton

The paper shows that chattering wheel slip is characteristic of all types of electric motive power. The application of the motive power in the electric and steam drives is compared, and the reason for the chattering wheel slip and the means of measuring and rectifying the same are given.

When the steam pressure in the cylinders of steam motive power is high enough to start slipping of drive wheels, their acceleration is fairly uniform and rapid, the load on the piston being well sustained on account of late cut-off and stored steam in pipes, receivers, etc.

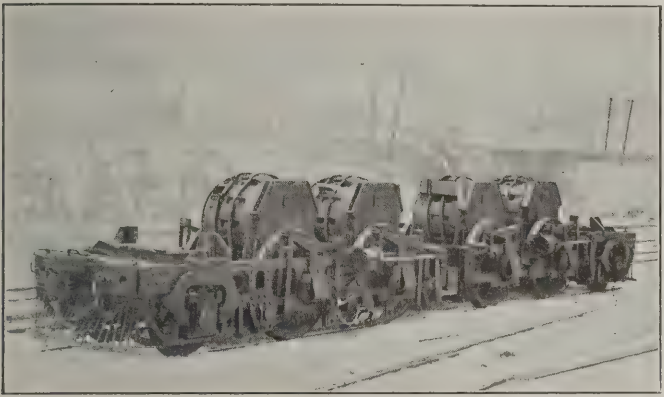

Fig. 1. Transmission of One Type of Geared Freight and Passenger Locomotive Where the Motors Are Geared Direct to Quill Axles

In contrast to this, with electric motive power, regardless of the method of transmitting the tractive effort from the rotors to the wheels, the acceleration after slipping starts is liable to be erratic, being dependent upon the distribution of rotating masses, and upon the characteristic of the coefficient of friction between wheel and rail.

The fundamental difference between the running gear of steam and electric motive power is that in the steam locomotive, the only moving parts having relatively high moment of inertia are the driving wheels.

In an electric locomotive, the moment of inertia of the rotors, especially when operating through a gear reduction, may be as great as or greater than that of the driving wheels.

The combined inertia of connecting rods, cross-heads, piston rods and pistons is practically negligible as far as it affects acceleration of driving wheels after slipping starts. In an electric locomotive, when slipping occurs, the sequence of events is as follows, regardless of the type of drive:

Current is applied to the motor and the rotor starts to turn. Clearances in the entire transmission mechanism are first eliminated. Then, as the torque is increased, the metal of the transmission, framing, etc., is bent and twisted, or otherwise deflected. This stressed metal becomes a storage battery of energy. Finally the tractive effort reaches a value sufficient to overcome the existing adhesion at the rail (coefficient of friction of repose), and the wheel starts to slip. The instant relative movement occurs between wheel and rail, the coefficient of friction drops from that of repose to that of relative motion. There is, therefore, an opportunity for the stressed metal to start discharging its stored energy, since part of the resisting force has disappeared. This energy is expended in accelerating the wheels ahead of the angular position they occupied relative to the rotor at the instant slipping started.

It is necessary next to analyze independently the two divisions of the rotating system, namely, rotors and wheels.

Since the wheels are being accelerated ahead of the rotors, the rotors are losing their load and will tend to speed up. This is true not only of motors of series characteristic, but also of induction motors when running below synchronism, as will ordinarily be the case in traction work when the wheels slip. In fact, the induction motors, because their generated counter e. m. f. with increased speed is less than with series motors, will hold up their torque better and, therefore, accelerate faster. The induction motor, in this particular, more nearly approaches the steam locomotive, in which, at starting, steam is cut off as late as possible in the stroke, so as to get the maximum starting tractive effort.

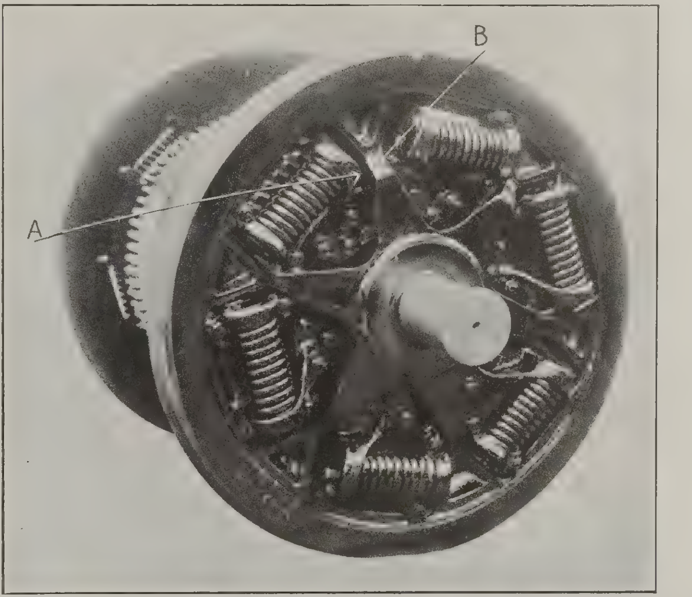

Fig. 2. Quill Supported Gear and Driving Wheels of Locomotive Transmission Shown in Fig. 1.

Analyzing next the other division of the system, the adhesion at the rail will decrease as the velocity of the wheel tread relative to the rail, increases. The effort being transmitted through the transmission system, however, will decrease very rapidly, due to expenditure of stored energy, and as soon as this effort, which is tending to accelerate the wheels, becomes less than the adhesion at the rail, which is tending to retard the wheels, the wheels will evidently start to slow down.

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*A paper presented at the fourth Mid-winter Convention of the American Institute of Electrical Engineers, New York, February 9, 1916.

There are, then, two sets of rotating masses mechanically coupled, the masses at one end of the system accelerating, and those at the other end, retarding. As soon as clearances in the transmission are taken up, there is liable to be a jolt on the mechanical system, accompanied by a recoil. This gives the setting for chattering action, and such action has been experienced in practically every type of electrically-driven rolling stock where the motors are sufficiently powerful to slip the wheels at high adhesion.

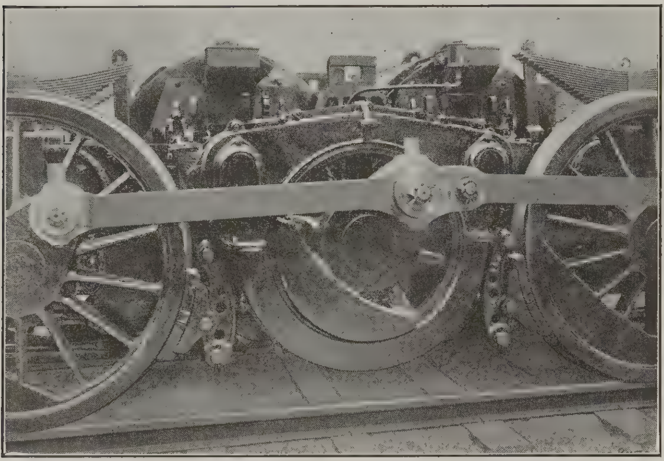


Fig. 3. Another Type of Electric Locomotive Transmission Where Two Three-Phase Motors Are Geared to a Jack Shaft Which Drives the Connecting Rods

This occurred on the geared freight and passenger locomotives whose transmission is shown in Fig. 1. The quill arms at the point marked *A* hit against the wheel spokes at the point marked *B*, Fig. 2, and more or less breakage of these arms occurred. It was found, however, that the arms which broke had blow-holes in the interior of the castings, and after these defective castings were eliminated, the breakage practically ceased.

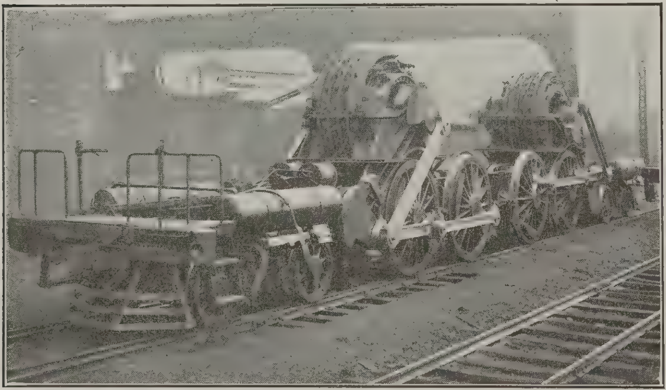


Fig. 4. A Type of Locomotive Transmission Where the Direct Current Motors Are Connected to the Jack Shaft by Connecting Rods

In later locomotives in the same service equipped with two motors per axle, the change in armature inertia eliminated this striking. Chattering slip still occurred, but the capacity of the quill springs was sufficient to limit the amplitude of swing to a distance less than the existing clearances.

A certain amount of similar striking again occurred in some switching locomotives, but here again the parts were strong enough to stand the service.

The same characteristic is occasionally observed in city and interurban cars, although this is much less frequent than in heavy hauling electric locomotives. This is due to the greater tractive power in proportion to the weight which is employed in the latter type of motive power.

In case of freight locomotives where the motors are geared directly to the axles the same phenomenon has been observed.

On the Norfolk & Western locomotives, chattering slip occurred in the running gear shown in Fig. 3. After the locomotives had been in service for some months, evidences of failure were detected in the crank pins. The cause was traced to chattering slip by means of a rough oscillograph, as shown in Fig. 5. The brakes were set on three trucks, and the oscillograph frame was set up on the fourth truck. The wheel tread was chalked. The oscillograph frame was oscillated about its supporting points *A*, Fig. 5, the amplitude of oscillation being two inches. The time of complete oscillation was two seconds. The scribers were pressed against the wheel tread. The wheel treads were then slipped, and the characteristic diagram of the chattering slip was obtained, as shown in Fig. 6. The analysis in the figure is self-explanatory. By means of this diagram, it was possible to figure approximately the forces necessary to produce the acceleration and retardation which occurred, and the resultant stresses in the rods, pins, etc., were calculated.

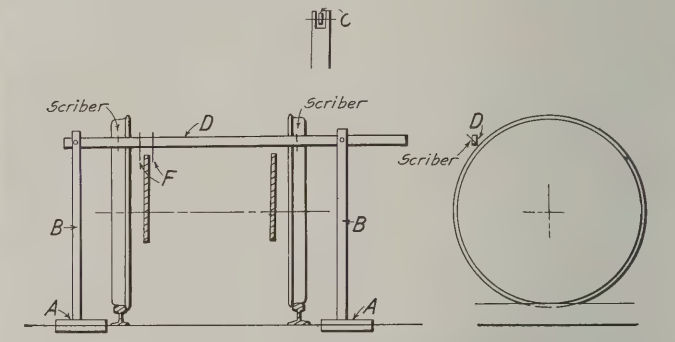


Fig. 5. Hand-operated Oscillograph for Recording Chattering Wheel Slip

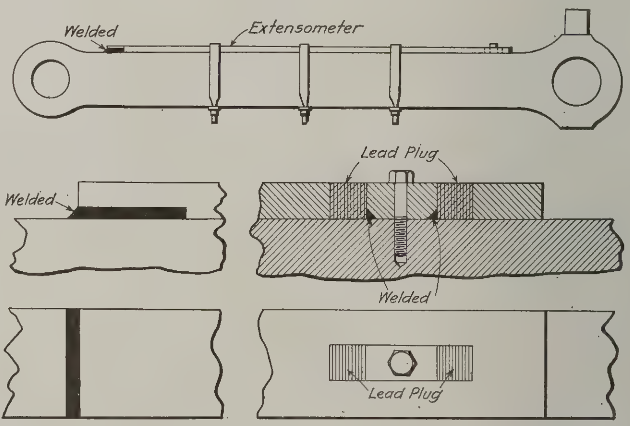


Fig. 6. Details of the Extensometers Used to Check the Oscillograph Figures

To check the oscillograph figures, extensometers were arranged, as shown in Fig. 7, by means of which the connecting rods indicated their own stresses. The extension and compression of the rods were recorded by means of the compression of blocks of lead. This is evident from a little study of the figure.

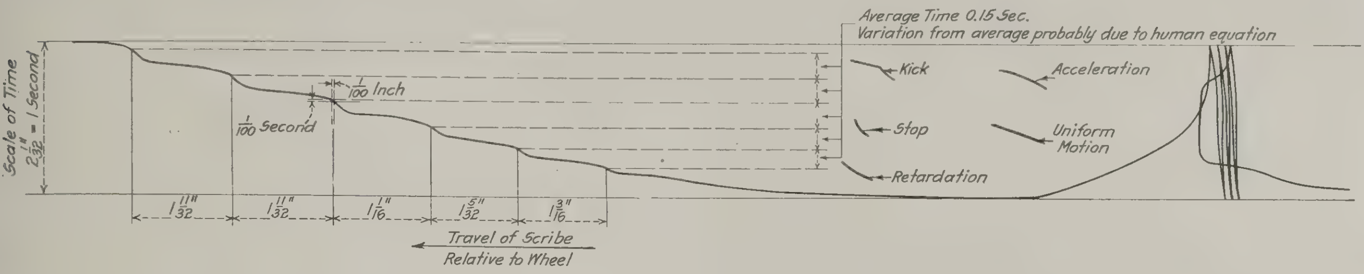


Fig. 7. Oscillograph Record of Chattering Wheel Slip. This Record Was Made Directly on the Wheel Tread

The two methods checked within a very few per cent. On the basis of the results, new rods, pins, etc., were applied on the locomotives. These have proved adequate for the service.

This chattering slip was more evident on the Norfolk & Western locomotives than could have been anticipated, since this was the first time electric haulage had been applied in service where such extremely high tractive efforts were required.

The phenomenon had never been observed on the locomotives with transmission as shown in Fig. 4. After it was experienced on the Norfolk and Western, however, permission was secured to make a test on the locomotives shown in Fig. 4. The wheels were slipped several times in succession in the same spot on the rails, and on the third slip, chattering occurred.

In all heavy hauling electric motive power, this problem must be considered, with every type of drive. The great number of variables entering and the wide fluctuation of certain of these variables render broad experience necessary in securing a successful solution of the problem. This has been gone into deeply and quantitatively by the writer and his associates, together with engineers of the locomotive works, with elaborate special testing apparatus, but it has been considered necessary to eliminate all quantitative values from this paper, the purpose of which is simply to cover the subject briefly.

Industrial Trucks in the Service of the Pennsylvania*

T. V. Buckwalter

The industrial truck as at present developed comprises several general classes, as governed by condition of service. These are:

Drop Frame Baggage Truck with Three Load Drop Frame Trailers. Steering Arrangement Permits of Operation Over Tortuous Course

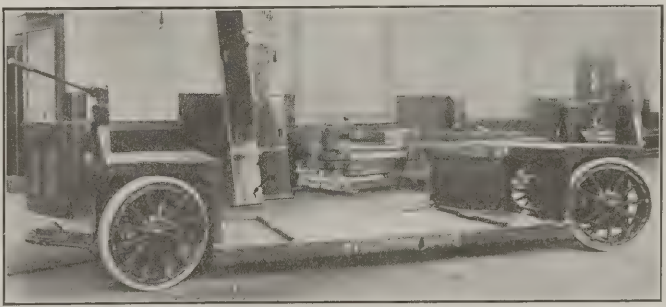
- Baggage and Mail trucks for use in Passenger Stations.
- Warehouse Trucks for Freight Stations and Warehouses.
- Shop Trucks for Railroad Shops and general industrial purposes.
- Electric Tractors for propelling freight cars over street railway track.

There are no well defined lines of demarcation between the first three classes and several modifications of each class have been constructed, as demanded by the condition at each installation.

Classes of Trucks

Baggage Truck.—The baggage trucks are characterized by a height of about two-thirds the distance from the platform to the baggage car floor. This works out at about 30 in. The length is controlled generally by existing elevator sizes and ranges from 9 to 12 ft. The width is slightly greater than the length of large trucks, generally 44 in.

A modification of the baggage truck has a body only 9 in. high for use in depressed track stations where the car floor is but slightly higher than the station platform.



Drop Frame Shop Truck with Transverse Rails for Carrying Mounted Wheels

Warehouse Trucks.—The electric warehouse trucks are characterized by a depressed portion at one end to facilitate loading, and delivery of the load into the end of the car.

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*A paper presented before the Electric Vehicle Association at Cleveland, Ohio, October 18 and 19, 1915.

The restrictions limit the height to about 10 in., the width to about 40 in. and the overall length to less than 9 ft.

Shop Trucks.—The use of shop trucks is subject to a variety of conditions as regards relative size and bulk of material handled. This has required a number of modifications in truck sizes.

A distinct shop truck class has therefore not been developed, but adoption made of baggage and warehouse classes.

Shop Truck, Warehouse Class, Commissary Department

Double End Control.—Railroad stations and shops are generally congested with runways as narrow as conditions will allow, therefore with the object of avoiding entirely the necessity of turning around, thereby blocking other traffic, railroad industrial trucks have been constructed with double end control. This feature permits of operation with equal facility in either direction, reducing congestion to a minimum.

An exception is the warehouse truck, which must have the low frame available for operation into freight cars.

Four-Wheel Steer.—Space required to turn is still further reduced by steering four wheels instead of two, and operation is made exactly identical in either direction. This eliminates the dangerous practice of running two-wheel steering trucks backward.

Two-Wheel Drive.—Sufficient traction for all ordinary work is available with two-wheel driving, and therefore four-wheel driving complication is avoided.

The voltage of industrial trucks has been selected after a careful study of the advantages of prevailing commercial truck standards and of much lower voltages, and was finally adopted at 24 volts as the minimum at which efficient motors were obtainable, in consideration of the preponderant advantages of the low voltage battery.

The 24-volt battery has the following advantages:

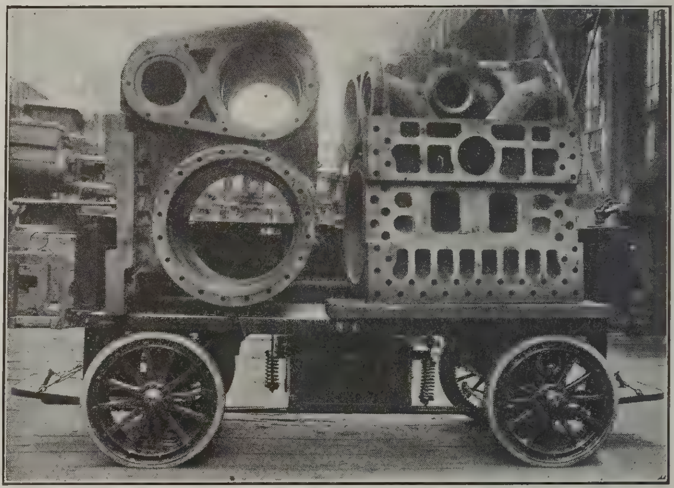
  Minimum number of cells.
  Minimum number of connectors.
Consequently,
  Minimum possibility of jar and connector breakage.
  Minimum cost per unit of capacity.
  Minimum weight per unit of capacity.

Capacity.—The capacity of industrial trucks was worked out at 4,000 lbs. as the maximum that could be readily and safely handled within narrow and congested enclosures, in consideration of the absolute necessity of quick stopping and positive and quick manipulation of control mechanism.

Larger than 4,000-lb. trucks are too cumbersome and smaller trucks do not handle enough to realize the full efficiency of the service.

A 50 per cent. overload factor has been found desirable, which makes a total weight as much as can be quickly handled.

Speeds.—High speed capacity has been found of little or no value for the reason that the speed is entirely a matter of condition and amount of congestion of runways, presence of other people who have other duties beside looking out for trucks. Therefore the speed has been gradually reduced as our experience increased to the present standard of six to seven miles per hour with the empty truck and five to six miles per hour loaded.



Shop Truck, Straight Frame Class

General.—The foregoing is intended as a general description of trucks designed to meet railroad conditions of service as these conditions appear to railroad men. If certain characteristics are considered essential in an industrial truck, every effort has been made to obtain such desirable characteristics, sometimes at an increased cost over simpler but less efficient structures.

Operating Results

It is understood this association is interested chiefly in operating results. The appended table entitled Summary of Operating Data, Year 1914, should be found particularly interesting.

This table shows all labor and operating charges for the year 1914 for a total of 212 trucks.

The table is arranged in two sections devoted to total charges for all trucks at each installation and averages per truck month for each installation.

There is naturally a wide variation in some of the charges, due to difference in current cost ranging from 5 mills to 10 cents per k.w.h. to the number of trucks in the installation, and the character of the work.

The shop trucks include labor charges of drivers, but the baggage trucks do not include these charges for the reason that the trucks are driven by the baggage porters.

The installations are given an efficiency standing based on saving on shop trucks and on cost of operation on baggage trucks. The former is computed on saving because these trucks handle work formerly done by manual labor, and the saving is readily computed. However, the figures do not represent the total saving, as, for instance, increased efficiency of the shop due to having material handled on a regular and prompt schedule does not admit of calculation. The old practice of helping out the labor gang with machinists is largely avoided.

The saving effected in baggage service is considerable, and some figures are available, but were not considered sufficiently complete to be presented at this time. This saving is difficult of calculation. The character of the service has changed considerably since the introduction of electric trucks the parcel post, formerly non-existent, is now a large and important part of the work. The labor force has not, generally speaking, been decreased, but on the other hand, the business has increased.

M.E 3422

SHOP TRUCKS

SHOP	NO OF TRUCKS	AVERAGE MONTHLY DATA ALL TRUCKS. LABOR			MATERIAL			KWH	CURRENT COST.	TOTAL COST	AVERAGES PER TRUCK MONTH			
		DRIVER	TRUCK REPAIRS	BATTERY REPAIRS & CHARGING.	TRUCK	BATTERY	TIRE				TOTAL COST	CURRENT COST.	SAVING	PERCENTAGE SEE NOTE 2.
HARRISBURG	1	48.98	2 62	1 76	1 88	4 40	5.38	209	5.43	70.47	70.47	5 43	154 80	100 %
VERONA.	1	39 96	8.30	2 74	1.56	1 09	3.48	587	8.81	82.94	82.94	8.81	154.68	99.8%
TRENTON	1	32.48	5 72	2 84	8.36	1 56	6.35	792	9.90	67.20	67.20	9.90	134 69	87. %
JUNIATA	2	76 64	13.23	11 82	5.36	11 42	1.73	1426	11.14	131 33	65.66	5.57	109.15	70.9%
ALTOONA CAR SHOPS	3	116.96	12 52	18.26	21.96	12 54		1251	8.57	190.81	63.60	2 85	96 12	62 %
RENOVO	2	92.95	2.84	12.35	1.63	8.28		1168	18.05	136.10	68 05	9 02	93.61	60.4%
MT CARBON	1	32 36	.39	2.38	.40	1.13		272	8.80	45.47	45.47	8.80	93 22	60 2%
ALTOONA MACH. SHOPS	9	560.42	88.96	38.89	48.79	13.72	29.77	2342	14.06	788.61	87 62	1 56	92.22	59 5%
PITCAIRN	4-5	168.46	44.48	30.24	22.07	22 64	20.81	789	4.05	312.75	67.99	88	89 64	57.9%
SOUTH PITTSBURGH	1	42 38	1.83	1.76	.28	.81		392	4 60	51 27	51 27	4 60	64 04	41 3%
MEADOWS SHOP	1		2 88	1 06	74	08		734	29.40	34 13	34 13	29 40	21 75	14. %
SUNNYSIDE YARD	11-14		40.89	14 32	22.78	3.21	12 80	4938	38.86	132 37	12 73	3 74		
WEST PHILADELPHIA	1	10 27	1 68	08	.01	06		208	1.44	13.54	13 54	1 44		
JERSEY CITY PIER L	3-6		30.10	30 93	22 18	35 05	5.38	1340	45 77	173 42	51.00	13.46		

BAGGAGE TRUCKS.

STATION	NO OF TRUCKS	AVERAGE MONTHLY DATA ALL TRUCKS LABOR		MATERIAL			KWH	CURRENT COST	TOTAL COST	AVERAGES PER TRUCK MONTH			
		TRUCK REPAIRS	BATTERY REPAIRS & CHARGING	TRUCK	BATTERY	TIRE				TOTAL COST	CURRENT COST	SAVING	PERCENTAGE SEE NOTE 3
BALTIMORE	2	6 54	6 02	1 30	62	1 53	953	11 50	27 50	13 75	5 75		100 %
PHILADELPHIA	34-36	87 55	94 36	128 52	12.30	8 19	4821	88 66	421 58	16 93	3 56		81 2%
PITTSBURGH	17-28	158.50	136 98	128 90	40 07	3 43	6731	34 86	503 13	17 97	1 25		76 5%
NEW YORK	64-66	188 11	172 03	248 73	475 38	23 64	5016	66.63	1184 48	18 08	1 02		76 1%
NORTH PHILADELPHIA	4-10	23.29	33 28	15 08	32 76	6 11	1534	43 56	154 09	24 85	7 03		55.3%
WASHINGTON	18	90 46	58 17	67 59	37.91	114.72	11810	85 88	455 00	25 28	4 77		54 4%
JERSEY CITY	3-5	40.88	17 66	16.24	21.48		956	19.12	115 38	28 58	4 80		46 5%
HARRISBURG	1	10 44	4 17	96	39 02		588	12.01	66.60	66.60	12 01		20 6%

1 THE EFFICIENCY STANDING OF EACH TRUCK INSTALLATION IS INDICATED ON A PERCENTAGE BASIS

2 SHOP TRUCK EFFICIENCY IS BASED ON SAVING IN LABOR EFFECTED.

3. BAGGAGE TRUCK EFFICIENCY IS BASED ON COST OF MAINTENANCE PER TRUCK MONTH

4 IN EACH CASE THE BEST SHOWING IS INDICATED AS 100% EFFICIENCY.

Summary of Operating Data for Electric Trucks for the Year 1914

Rush periods can now be handled without borrowing untrained men from other departments. A better class of men continue in service, as compared with the rapidly changing force in the old days.

The operating people consider that the most important advantage of electric baggage trucks is relief to terminal congestion and prompt despatch of trains resulting from avoidance of baggage detention.

The saving effected is not stated on certain installations. This does not indicate absence of saving, but failure of operating people to ascertain same in time for this paper. The installations omitted would be near the top of the list.

Under the heading "Number of Trucks" is indicated the number at the beginning and the end of the year but averages are based on actual truck months.

Electric Tractor

The electric Tractor has now been in service 31 months and has proved entirely satisfactory. A description of this machine will be found in the S. A. E. Proceedings, Year 1914, Page 231. A brief description, however, may be of interest.

The machine is intended to replace horses in the operation of freight cars on track laid on paved streets. The tractor runs on the pavement and the fundamental reason for the success following its operation is the ability to be operated without confinement to rails.

Cars can be handled from either end by either end of the tractor.

Steering, driving and braking is on four wheels.

The tire size is 60 in. x 6 in. dual. Weight 29,000 lbs.

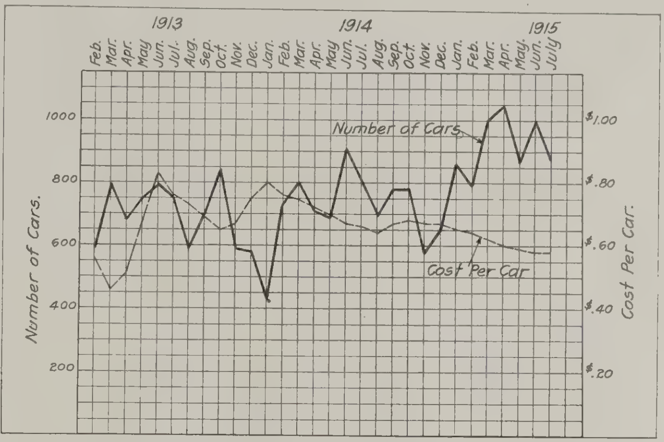
Draw bar capacity 8,000 lbs. at 2 m. p. h.

Normal Speed 6 m. p. h. with one car on level tangent.

Brakes can be operated by hand or automatic air.

Radial draft gear with standard couplers is provided at each end.

The diameter of the stearing wheel is 42 in. with other parts in proportion.



Curves of Electric Tractor Operation Showing Number of Cars Handled Per Month and Cost Per Car Per Month Since January, 1913

The brake shoes are four in number, 2½ in. wide by 30 in. diameter.

Driving gears are 33 in. diameter and 4 in. wide on each wheel.

The machine is shown on appended photograph.

The results of operation is shown on the attached table.

Data Derived from Above Tables

Cost of tractor		$13,400.00
Cost of maintenance and operation, 2½ years	$13,145.67	
Interest at 6 per cent on $13,400, 2½ years	2,010.00	
Depreciation, less tires and battery, $13,400 — $4,200 = $9,200, @ 5 per cent, 2½ years	1,150.00	
Depreciation battery $3,200 @ 25 per cent, 2½ years.	2,000.00	
	$18,205.67	
Total cost of service, 2½ years		18,205.67
Total number of cars (in and out) 2½ years	22,639 cars	
Total cost of service if horses had been used, 22,639 x $1.86		42,108.54
Saving by electric tractor, 2½ years		23,902.87
Saving over investment, 2½ years		178.4%
Saving over investment, 1 year		71.4%
Total cost of service per car, 18,205.67 ÷ 22,639		$0.805
Average weight per car		33,196 tons
Cost of service per ton (in and out)		$0.0243
Total miles operated		8,804.3 miles
Total number cars handled in internal movements		15,202 cars
Grand total cars (in, out and internal)		37,841
Cost of maintenance and operation per car (in, out and internal), 13,145.67 ÷ 37,841		$0.347
Cost of maintenance and operation per ton (in, out and internal)		$0.0104
Cost of maintenance and operation per mile, 13,145.67 ÷ 37,841.		$1.49
Total length all cars handled, 37,841 x 40 ft		287 miles
Cost of service per working day by tractor, 18,205.67 ÷ 738 days		$24.67
Cost of service per working day by teams, 42,108.34 ÷ 738 days		57.06
Saving per day		32.39

The attached curve shows the growth of service in number of cars handled per month and indicates gradual growth of from 690 to 920 cars per month during a period when railroad business has been stationery. At the same time the cost per car has decreased from a maximum of 83 cents to 58 cents.

Other interesting data may also be mentioned.

Loss of time in 2½ years is nine days due to failure of the machine.

Saving over investment 71.4%, saving per day $32.39.

In travelling 8804 miles the machine has handled cars aggregating 287 miles in length.

Cost of service per ton based on cars in and out is 2.4 cents but operating cost on all cars handled is only 1.04 cents per ton.

Internal movements have reference to cars moved from point to point within the trackage operated by the tractor. These movements were not included in total costs in service.

It is hoped this paper will encourage other users of electric trucks to submit actual operating data based on service of these machines.

Average Daily Performance of Electric Tractor by Months

1913	Hours on charge	Hours in service	Discharge in amp. hrs.	Miles	Number of cars handled			Internal movements	Total weight, tons	Days in serv.	Days out serv.
					In	Out	Total				
February	8.2	8.5	616	12.1	14.8	14.8	29.6	19.5	992	...	.....
March	7.3	8.5	508	12.6	15.3	15	30	19.4	1,032	...	.....
April	7.9	9.5	518	13.7	15.7	16.5	32.3	20.9	1,100	...	.....
May	7.3	8.5	510	14.8	17	17	34.1	17.3	1,118	...	.....
June	6.7	8.6	494	13.1	15.7	15.9	31.6	14	1,057	...	.....
July	6	7.7	410	14.4	14.4	14.4	28.7	13.6	962	...	.....
August	5.5	6.7	344	10.3	11.4	11.4	22.8	14.3	763	...	.....
September	7	6.1	432	11.3	13.9	13.9	27.8	16.2	931	...	.....
October	7	7.8	511	12.4	15.7	15.3	31	23.8	1,070	...	.....
November	6.2	6.6	433	11.2	12.8	13	25.8	20	855	...	.....
December	6	6.7	415	9.7	10.9	11.6	22.4	20	752	...	.....
Average	6.8	7.7	472	12.3	14.3	14.4	28.7	18.1	967	...	.....

Totals by Months

1913											
February	164	168	12,120	241.5	297	296	593	390	19,842	20	.....
March	190	220	13,230	328.3	398	390	788	504	26,837	26	.....
April	166	199	10,890	280.9	330	346	676	438	23,082	21	5
May	160	186	11,225	325	375	375	750	380	24,600	22	4
June	167	215	12,330	327.9	393	397	790	351	26,433	25	.....
July	156	199	10.430	303.7	374	373	747	354	25,005	26	.....
August	144	174	8,940	268.7	296	295	591	371	19,775	26	.....
September	175	152	10,790	294.4	347	349	696	421	23,288	26	.....
October	190	210	13,820	334	424	414	838	643	28,877	27	.....
November	142	152	9,970	257.7	293	298	591	458	19,775	23	.....
December	175	175	10,790	251.2	285	299	584	519	19,540	26	.....
Total	1,809	2,050	124,535	3,213.3	3,812	3,832	7,644	4,829	257,054	268	9

Average Daily Performance of Electric Tractor by Months

1914	Hours on charge	Hours in service	Discharge in amp. hrs.	Miles	Number of cars handled			Internal movements	Total weight, tons	Days in serv.	Days out serv.
					In	Out	Total				
January	7.5	7.2	605	11.7	14.1	13.1	27.1	22.1	905	...	.....
February	8.9	8.9	806	14.9	16.8	16.5	33.3	19.1	1,115	...	.....
March	7.9	8	616	12.5	15.9	16	31.8	21.6	1,065	...	.....
April	6	6.5	449	10.5	13.5	13.8	27.3	19.8	912	...	.....
May	6.2	7	375	10.6	14	14	27.8	20.8	925	...	.....
June	6.5	7.9	452	12.3	17.7	17.5	35.2	21.7	1,172	...	.....
July	5.8	7.5	415	11.8	15.3	15.5	30.8	21.4	1,031	...	.....
August	5.2	6.5	356	10.3	13.5	13.3	26.9	19.2	902	...	.....
September	5.8	7.5	384	12	16.6	17.1	33.7	22.3	1,130	...	.....
October	6.2	7.9	357	11	14.4	14.4	28.8	18.5	965	...	.....
November	6.9	8.2	425	10.2	12.8	12.2	25	20.2	839	...	.....
December	7	8	492	9.9	12.1	12.8	24.9	19.2	835	...	.....
Average	6.7	7.6	478	11.5	14.7	14.7	29.4	20.5	983	...	.....

Totals by Months

1914											
January	120	114	9,680	187.4	223	210	433	354	14,488	16	1 loaned
February	195	196	17,730	327.5	370	362	732	420	24,493	22	1 no cars
March	197	201	15,410	313.1	397	399	796	540	26,634	25	1 no cars
April	161	178	11,660	268.5	351	358	709	516	23,723	26	.....
May	154	174	9,370	264.4	348	346	694	522	23,121	27	.....
June	170	204	11,740	319.3	460	454	914	566	35,582	26	.....
July	152	195	10,800	308.7	398	403	801	557	26,801	26	.....
August	136	170	9,270	268.3	353	348	701	499	23,455	26	.....
September	135	173	8,830	277.0	383	394	777	514	25,998	23	2 painting
October	168	213	9,650	298.4	390	389	779	501	26,065	27	.....
November	160	189	9,880	236.2	295	282	577	466	19,306	23	.....
December	183	209	12,800	258.7	316	333	649	501	21,716	26	.....
Total	1,931	2,216	136,820	3,328	4,284	4,278	8,562	5,956	291,382	293	.....

Average Daily Performance of Electric Tractor by Months

1915	Hours on charge	Hours in service	Discharge in amp. hrs.	Miles	Number of cars handled			Internal movements	Total weight, tons	Days in serv.	Days out serv.
					In	Out	Total				
January	9.2	8.9	604	12.4	17.3	16.9	34.2	20.7	1,147	...	.....
February	9.5	8.3	660	13.6	18.1	17.9	36.1	25.5	1,208	...	.....
March	9	8.4	594	13.1	18.3	18.5	37	28.7	1,240	...	.....
April	8.3	8.3	512	13.7	20	20	40	30.8	1,345	...	.....
May	6.9	7.5	425	11.8	17.3	17.7	35	24.4	1,169	...	.....
June	7.1	8.4	468	13.4	19.3	19.2	38.5	24.5	1,286	...	.....
July	6.6	7.9	419	11.9	16.9	16.4	33.4	20.1	1,116	...	.....
Average	8.1	8.2	526.1	12.8	18.2	18.1	36.3	25	1,215.8	...	.....

Totals by Months

1915											
January	232	223	15,090	311	433	424	857	518	28,675	25	.....
February	211	183	14,530	290.1	400	394	794	562	26,567	22	.....
March	242	227	16.040	352.3	496	504	1,000	775	33,460	27	.....
April	216	217	13,320	354.3	521	519	1,040	798	34,798	26	.....
May	172	187	10,630	295.7	432	442	874	609	29,244	25	.....
June	183	219	12,160	349.7	501	498	999	633	33,426	26	.....
July	171	205	10,910	309.9	441	427	868	522	29,043	26	.....
Total	1,427	1,461	92,680	2,263	3,224	3,208	6,432	4,417	215,203	177	.....

Cost of Maintenance and Operation

1913	Repairs	Supplies	Cost of lub.	Driver	Current	Insurance	Labor	Total	Cars	Cost per car	Kw. hrs.	Cars from Jan.	Cost per car	Cost from Jan.
January	$11.82	$3.71	$1.08	$64.06	$5.14	......	......	$85.81	.....	.....	.....	.....	.....	$85.81
February	11.78	2.02	1.13	139.14	91.38	......	......	245.45	594	$0.41	.....	544	$0.558	331.26
March	100.82	6.40	1.18	105.18	94.45	......	......	308.03	788	.39	.....	1,382	.463	639.29
April	183.86	13.38	1.55	125.89	92.19	......	......	416.97	676	.62	.....	2,058	.513	1,056.26
May	538.39	3.67	1.58	141.52	122.05	......	......	817.20	750	1.09	.....	2,808	.667	1,873.46
June	894.94	9.43	1.12	140.08	73.97	......	......	1,120.34	790	1.42	.....	3,598	.832	2,993.80
July	59.36	2.59	8.10	146.09	103.39	......	......	319.53	747	.43	.....	4,345	.763	3,313.33
August	16.71	5.01	2.82	161.85	96.40	......	......	282.79	591	.48	.....	4,936	.728	3,596.15
September	4.97	4.63	.29	146.27	106.24	......	......	262.40	696	.377	5,111	5,632	.685	3,858.52
October	32.17	.84	31.39	155.82	118.81	......	......	339.03	838	.405	4,696	6,470	.648	4,197.55
November	306.06	1.90	9.33	150.30	91.38	......	......	558.97	591	.946	3,800	7,061	.673	4,756.52
December	638.03	104.92	3.28	145.00	82.94	......	......	974.17	584	1.67	3,770	7,645	.749	5,730.69
1914														
January	488.16	.31	.....	104.09	95.01	......	......	709.07	433	1.64	3,374	8,078	.797	6.439.76
February	11.25	2.92	.....	132.90	129.85	......	......	276.90	732	.32	5.514	8.810	.762	6,716.66
March	184.22	2.54	.54	139.72	120.13	......	......	447.15	796	.56	5,469	9,606	.746	7,163.81
April	19.19	153.23	.....	135.01	95.91	......	......	268.24	709	.378	4,134	10,315	.721	7,432.05
May	26.43	4.58	8.25	128.97	79.18	......	......	247.41	694	.356	4,134	11,009	.697	7,679.46
June	83.98	8.78	.....	137.13	81.29	......	......	311.18	914	.34	3,899	11,923	.67	7,990.64
July	145.26	4.66	.....	140.37	85.98	......	......	376.37	801	.469	3,605	12,724	.657	8,367.01
August	19.83	1.34	2.02	144.42	78.63	......	......	246.24	701	.351	3,403	13,425	.641	8,613.25
September	733.63	2.54	.84	137.45	73.27	......	......	947.73	777	1.22	3,177	14,202	.671	9,560.98
October	365.96	6.02	1.95	90.86	83.81	......	$38.97	587.57	779	.754	3,667	14,981	.677	10,148.55
November	115.96	3.20	1.09	62.79	78.81	......	58.82	320.67	577	.599	3,945	15,558	.672	10,469.22
December	133.79	1.45	8.25	73.54	101.81	......	55.81	374.65	649	.677	3,945	16,207	.669	10,843.87
1915														
January	28.65	6.45	.50	72.67	94.05	......	69.36	271.71	857	.377	3,945	17,064	.651	11,115.58
February	75.44	1.54	.84	61.72	86.93	......	64.61	291.08	794	.366	3,566	17,858	.638	11,406.66
March	91.65	2.94	1.12	74.02	82.57	$12.50	77.51	342.11	1,000	.342	4,874	18,858	.623	11,748.77
April	16.91	2.65	12.82	70.76	68.42	12.50	69.58	253.64	1,040	.244	4,169	19,898	.603	12,002.41
May	139.50	7.21	.....	61.83	60.81	12.50	56.47	338.32	874	.387	3,646	20,772	.594	12,340.73
June	27.51	8.48	.....	71.92	63.48	12.50	60.84	244.73	999	.245	3,844	21,771	.578	12,585.46
July	343.79	1.40	.....	76.35	70.36	12.50	55.81	560.21	868	.646	3,409	22,639	.58	13,145.67

A Code for Better Lighting*

III

Believing that the proper illumination of railway offices, depots, shops, freight warehouses, docks, etc., is a most important factor in preventing accidents, in producing greater accuracy of workmanship and in increasing labor efficiency, we are reprinting, in short, readable articles, a Code of Lighting, prepared by committees of the Illuminating Engineering Society. This code is a practical summary of information pertaining to the illumination of shops and other work places.

The first article appeared in the January issue.

SECTION II. VALUE OF ADEQUATE ILLUMINATION.—Factory and mill owners are concerned in the matter of securing the largest output for a given manufacturing expense. An improved machine tool capable of increasing the product for given labor costs is most attractive, provided its first cost is within returnable limits out of the larger profits. Improved small tools, better methods of handling material, adequate crane service, fire protection, good shop floors, accurate and efficient time-keeping methods, and similar items, vitally concern the shop manager; money is expended to realize excellence in these features because they afford increased economies and protection, thus resulting in a higher efficiency of the plant.

Effect of Good Light on Production.—Arguments of a convincing nature, which insure to the factory or mill manager an increased output through improved illumination service, are of importance and even greater at times than reductions in the cost of illumination for the same quantities of light. In view of the fact that resulting advantages of superior illumination on increased output are apt greatly to exceed economies in operation cost as regards the lighting system, it is a distinct advantage to direct and hold the attention on the former rather than on the latter. This statement will be more apparent when interpreted into definite items as follows:

Advantages of Good Light.—While the necessity of good natural and artificial light is so evident that a list of its effects may seem commonplace, these same effects are of such great importance in their relation to factory and mill management, that they are well worth careful attention. The effects of good light, both natural and artificial, and of bright and cheerful interior surroundings, include the following items:

1. Reduction of accidents.
2. Greater accuracy in workmanship.
3. Increased production for the same labor cost.
4. Less eye strain.
5. Promote better working and living conditions.
6. Greater contentment of the workmen.
7. More order and neatness in the plant.
8. Supervision of the men made easier.

In this list it will be noted that items 4, 5, 6, 7 and 8 all have a bearing on accident prevention.

Interpreting the Advantages of Good Light.—While the major consideration in the eyes of the factory or mill owner is undoubtedly and quite naturally the money value of good light in the larger return of both quantity and quality of work which may result from the installation of a superior as compared with an inferior lighting system, it should be noted that it is very difficult to interpret into dollars and cents the value of good light made possible by such returns. This difficulty is due to the necessity of keeping all conditions in a factory or mill section absolutely constant while varying the amount of illumination from poor to good conditions, in an effort to determine the output and its dependency on the lighting facilities. *As accurate data becomes available,* giving the increases in production for certain specific improvements in artificial lighting, it will doubtless prove helpful to a proper interpretation of adequate light and its worth to any plant.

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The eight foregoing points are emphasized as forming the most important features in the problem of good lighting. Although difficult to interpret into money values, and somewhat intangible, they are indisputable arguments in favor of the best available illumination from the standpoint of the factory or mill owner.

Practical Example.—Continuing from the manufacturer's point of view, it may be said that certain assumptions as to energy cost, cleaning, interest and depreciation, show that the annual operation and maintenance cost for the illumination of a typical shop bay of 640 square feet area, may be taken at $50.00. If five workmen are employed in such a bay at an average wage of say 25 cents per hour, the gross wages of the men in such a bay, plus the cost of superintendence and indirect shop expense, may equal from $5,000 to $7,000 per annum. In a case of this kind, therefore, the lighting will cost from 7/10 to 1 per cent. of the wages, or the equivalent of less than 4 to 6 minutes per day. We may roughly say that a poor lighting system will cost at least one-half this amount (sometimes even more through the use of inefficient lamps and a poor arrangement of lamps), or the equivalent of say 2 to 3 minutes per day. Nearly all factories and mills have at least some artificial light, hence, in general, if good light enables a man to do better or more work to the extent of from 2 to 3 minutes per day, the installation of good lighting will easily pay for the difference between good and bad light, through the time saved for the workmen.

Actual Losses.—Superintendents have stated in actual instances, that due to poor light their workmen have lost much time, sometimes as much as from one to two hours per day on certain days. If good light will add an average of say one-half an hour per day to the output, these 30 additional effective minutes represent an increase in output of 5 per cent., brought about through an expenditure equal to ½ of 1 per cent. of the wages for improved lighting, or a saving equal to ten times the expense.

Safety.—While these features are of special interest in the eyes of the manufacturer, the principal item to consider, perhaps, from the legislative side of the question, is the necessity of an act or acts to provide employees of workshops with proper and sufficient illumination from the standpoint of safety. The legal aspect of the safety question in its relation to illumination in factory and mill buildings is a topic of unusual importance.

SECTION III. OLD AND NEW LAMPS.—The inadequate means available for illumination by artificial methods in the past have contributed to the slowness of an appreciation of the features of artificial light which influence the working efficiency of the eye. Open flame gas burners, carbon incandescent and arc lamps, practically the only illuminants available ten years or so ago, play but a small part in the present approved methods of factory and mill lighting.

New Lamps.—The large variety of comparatively new lamps available for factory and mill lighting includes the mercury vapor, metallized filament, tungsten, gas filled tungsten, metallic flame or magnetic arc, the flame carbon arc, the quartz mercury vapor, and various types of gas arc lamps. Remarkable improvements have thus been made in both the electric and gas lighting fields, the same general rules of applying the lamps covering both of these fields. Possibilities in factory and mill lighting are now attainable which, before the introduction of these new lamps, were either unthought of or impossible. Consideration of the eye as a delicate organ, together with the new ideas of the items which affect its comfort and efficiency, have resulted in establishing certain principles in illumination work, and have directed attention naturally and in a growing manner to the proper use and application of these new lamps.

SECTION IV. EFFECTS ON FACTORY AND MILL LIGHTING PRODUCED BY MODERN LAMPS.—With the introduction of these new gas and electric lamps, broader possibilities have been presented in factory and mill lighting. The use of units of sizes adapted to the purposes, allows results which it has been hitherto impossible to obtain satisfactorily, either by the arc lamp, carbon filament or open flame gas burner, formerly available.

New Possibilities.—It is evident that the introduction of the many new lamps has made possible what may be termed a new era in industrial illumination, a distinctive feature of which is the scientific installation of the lighting units, suiting each to the location and class of work for which it is best adapted. Before the availability in recent years of medium sized gas and electric units the choice of the size of unit for a given location was often no choice at all. In many cases, due to small clearance between cranes and ceilings, or other conditions making it necessary to mount the lamps very high above the floor, but one size or type of unit was available, the carbon filament or open flame gas burner in the former, and the arc lamp in the latter case.

Low Ceilings.—For low ceilings, up to 18 feet, the use either of carbon filament, open flame gas burner, or arc lamps resulted usually in anything but uniform light over the working plane, and often produced merely a low general light which was practically useless for the individual machine. In such instances, individual lamps had to be placed over and close to the machines. With this arrangement, relatively small areas are lighted by each lamp, and the metal shades usually employed serve only to accentuate the "spot lighting" effect. Such a form of illumination for factory and mill work is unsatisfactory and inefficient, but, as stated, was in the past, in many cases, the only available scheme. *The absence of lamps of the proper size is no longer an excuse for the existence of such conditions in industrial plants.*

SECTION V. GENERAL REQUIREMENTS OF ARTIFICIAL LIGHTING.—The following requirements for factory and mill lighting are made all the more important by the peculiar limitations and the wide variety of conditions to be found in factory and mill buildings and in factory and mill work:

1. Sufficient illumination should usually be provided for each workman irrespective of his position on the floor space.
2. The lamps should be installed and selected so as to avoid eye strain to the workmen.
3. The lamps should be operated from sources of supply which will insure reliable illumination results, particularly on account of the demoralizing effect produced by intermittent service when the light is most needed.
4. Adequate illumination should be provided from

overhead lamps so that sharp shadows may be prevented as much as possible, and in such measure that individual lamps close to the work may be unnecessary, except in special cases.

5. The type and size of lamp should be adapted to the particular ceiling height and class of work in question.

6. In addition to the illumination provided by overhead lamps, individual lamps should be placed close to the work if they are absolutely necessary in the eyes of a lighting expert, and in such cases the lamps should be provided with suitable opaque reflectors.

These requirements may now be met by means of the new types of gas and electric lamps, one type of which can usually be found for practically each factory and mill location, specially adapted to the general physical conditions of the location as typified by the clearance between cranes and ceiling and other similar items.

SECTION VI. OVERHEAD AND SPECIFIC METHODS OF ARTIFICIAL LIGHTING.—Factory and mill lighting may be classified under two general divisions: first, distributed illumination furnished from lamps mounted overhead, and second, specific illumination furnished by individual lamps located close to the work. For practical purposes this classification is sufficient. In numerous cases a combination of these two methods becomes necessary.

Mounting the Lamps High.—Where the lamps are high enough to be out of the line of ordinary vision, and are of a size and so spaced as to furnish illumination at any position of the floor where work may be carried on, the system is referred to as the *overhead method* of lighting. This method has many advantages. Its general adoption, which has been somewhat slow, has increased with the appearance of the many new types of lamps and with the growing appreciation of the value of good lighting.

Where a small amount of general or overhead lighting is coupled with specific lighting from individual lamps, a large part of the floor space in many shops is in relative darkness, and much dependence must be placed on the hand lamps close to the work. The small number of overhead lamps generally used in such cases, furnishes merely a small amount of additional illumination over the floor space which is not sufficient to be of much value. However, where sufficient intensity is provided by general illumination, this is often a very effective means of lighting a large workroom.

Low Ceilings.—Locations with low ceilings, until recently, have been lighted by the individual hand lamp method, because the old carbon filament lamps, being of low candlepower, could not well be used close to the ceiling, while the old type of arc lamp was often impracticable, due to its large physical size, as well as its relatively high candlepower. This statement is subject to some modification, because low candlepower units have sometimes been used in clusters for low ceilings as a compromise between a single small or a single large unit, this scheme being, however, usually insufficient and unsatisfactory in comparison with modern methods of lighting. In a particular manner, therefore, suitable illumination has been difficult with low ceilings.

New types of gas and electric lamps have a range of candlepower from very low to very high values, and the overhead system with the elimination of individual lamps is thus possible; in other words, a size of gas or electric lamp may now be selected from a large available list of sizes for nearly every factory or mill condition.

Shop Motor Section

Transformers

J. H. Wickman*

XVI

The transformer is a piece of electrical apparatus that is designed to take alternating current from the supply mains at a certain voltage and frequency and to deliver current to a receiving circuit at a different voltage but at the same frequency. There is but one condition that must be precisely met in its design and that is the ratio of primary to the secondary turns must be equal to the ratio between the prescribed primary and secondary voltages. All other points of design are but a matter of choice, to be determined by experience. Nevertheless, the designer of transformers should strive for:

1—Good insulation,
2—Good regulation,
3—High efficiency,
4—Small open-circuit current,
5—Small rise in temperature,
6—Low first cost,
7—High safety factor.

Some of these conditions are opposed to others, as, for example, high efficiency and low first cost. The allowable temperature rise varies widely with the different makes, also the extent of radiating surface required per watt loss per degree rise in temperature varies between extremely wide limits, hence no simple rule can be given to govern these matters.

Construction

The transformer is made essentially of three materials, namely: copper, steel and insulation. The copper is in wire form, wound on the core which is composed of laminated iron or steel. Designers of transformers are using Silicon steel because cores made of this steel are non-aging. After the winding is done, the assembled coils and cores are placed and fastened in an iron case. The coil leads are then brought out through the insulating bushings to the outside for connection purposes.

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Cores and Coils

The coils of most transformers are form wound and surround the laminated core. An assembled core manufactured by the General Electric Company for one type of transformer is shown in Fig. 1. It is built up of laminated steel without the use of any insulating material between the sheets of steel, as is generally used to prevent eddy currents, and then riveted together, the rivets being insulated from the core proper.

The shape of a core built up in the manner shown provides a better duct for the insulating oil to flow in and thereby lessens the heating effects. The assembling of the coils and the core is very simple. If the core is of the solid constructed form shown in Fig. 1, the coil is slipped over the core, but if the core is to be laid up piece by piece around and in the coil, the coils are wound on a form, then the small pieces of the core are placed, one by one, around the coils.

Different manufacturers assemble the coils in various ways, some have the secondary coil next to the core, some have the primary next to the core and others mix the two by placing different layers of the secondary next to the layers of the primary. There is no stated law or rule governing this point.

Transformer Cases

The design of the transformer case depends upon the type of transformer to be placed within it, and upon the cooling system used. Usually, however, they are made of cast-iron. Large air-cooled transformers have upright standards at each corner and a cast cover with an air damper within it. The center part between the standards is sheet-iron fastened to the upright parts by machine screws. The type of case that would be used for the core shown in Fig. 1 is a one-part cast-iron case provided with a cover of the same material.

Types of Transformers

The student will gather from the preceding paragraph that there are different types of transformers and that each type derives its name from the method by which it is cooled, namely (1) oil cooled, (2) air cooled, and (3) water cooled.

Oil Cooled Transformers

After the coils and core are placed within the case, it is filled nearly to the top with oil which carries the heat generated by the coils to the case from which it is dissipated into the air. The coils are therefore kept at a safe operating temperature, providing the transformer is not overloaded.

Air Cooled Transformers

The laminations are separated by fillers, placed between them to allow a circulation of cool air to pass through, which collects the heat and is forced to some outside duct, thereby cooling the transformer. The air is supplied from a fan which receives its air supply from an out-of-door source. The air is forced into the transformer from the bottom side, through and around the core and coils, thence out through the damper at the top. The air pressure used for cooling transformers varies from one to four ounces per square inch. Like the oil cooled transformer, this type will remain at a safe temperature, if not overloaded.

The motors that are generally used for running the blower set are, as a rule, connected to the secondary side of the transformer which is to be cooled, and are self-starting. In this way the blower set operates only when the transformer is being used. If the blower motor was connected to some other circuit and if this circuit failed the transformer would soon be damaged due to overheating. The correct size of blower motor varies according to the pressure carried and the size of transformer to be cooled—the per cent of total output of the transformer used in cooling is but small, often not amounting to more than 1 or 2 per cent.

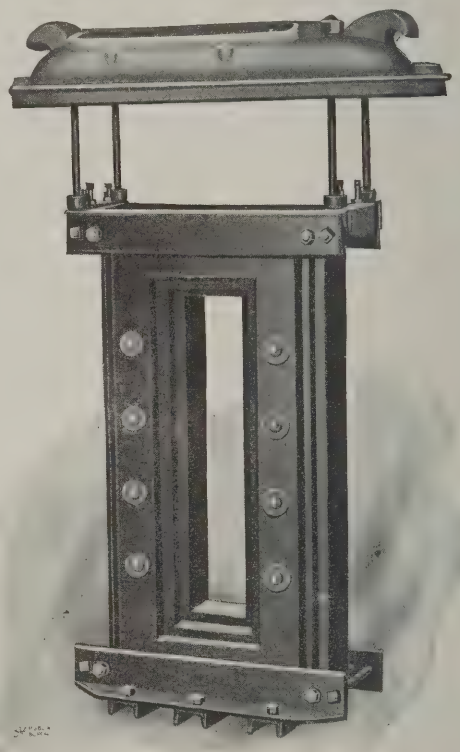

Fig. 1. An Assembled Core for One Type of Transformer.

Water Cooled Transformer

This type of transformer resembles the oil cooled transformer and like it is filled with oil. The water coils are placed within the case and are covered with oil. The circulation of the water by convection currents cools the oil which in turn cools the coils and core.

The water cooled transformer, like the air blast transformer, will safely operate but a very short time without water, but this type of transformer may be overloaded to a greater extent than either of the two heretofore mentioned, because of its greater radiating properties.

Transformer Oil

A special grade of oil known as transil oil, which has been found by experience to be best suited for the purpose, is used for all insulated transformers. This oil will absorb but little moisture from the air even when directly exposed to it, but moisture may collect on the interior portions of the case which are not covered withm oil, or on the upper surface of the oil itself if the case is considerably below the temperature of the surrounding air. Little danger can arise, however, if the transformers are continually used and if the air in the room is kept at about the same temperature.

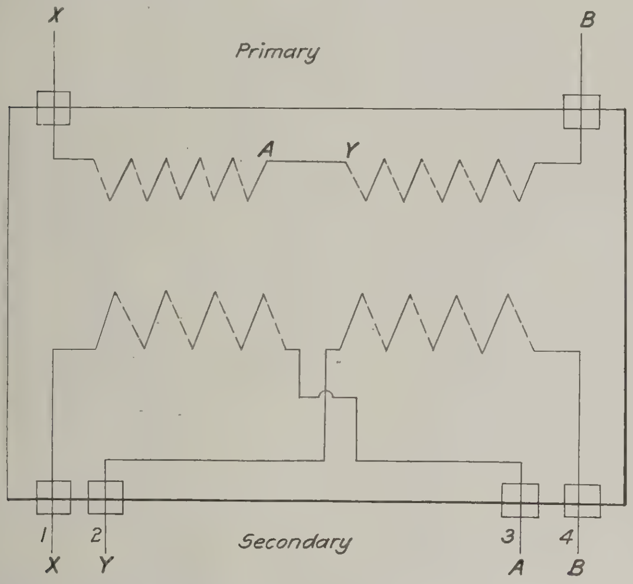

Fig. 2. Diagram Showing How the Connections to the Coils in a Typical Transformer Are Brought Out of the Transformer Case.

Transformers that are to be operated on a high voltage circuit must be filled with the very best transil oil obtainable and all such oil should receive a spark gap test before using, so that the breakdown voltage will be known. A voltage break down test may be made as follows: A graduated cylinder (preferably glass) is filled with oil to be tested, the bottom having a contact terminal in it. The other terminal is lowered to within a small fraction of an inch of the bottom terminal and the voltage applied. The testing voltage is supplied by a transformer from which a varying voltage may be obtained and to which a voltmeter is connected to take readings. The voltage is regulated until a breakdown of the oil insulation is noticed, which occurs when small bubbles of gas and oil pass from one terminal to the other and a cracking noise is heard, and the oil appears to vaporize as smoky bubbles. At this point a reading should be taken from the voltmeter.

The presence of a very little moisture in transil oil will materially lessen its insulating qualities. Test records show where oil had stood 40,000 volts with a dry tube, but when the test tube was moistened by means of the breath and the oil put back and retested, it broke down at 15,000 volts.

To realize the high insulating properties of transil oil, tests on record show 33,000 volts broke down the insulation of a two-inch air gap and 40,000 volts broke down a 2⅞-inch air gap, yet at the same time it required 48,000 to 63,000 volts to break down the insulating properties of oil with a spark gap of only ⅛ in.

Treatment of Oil

If transformer oil does not hold up to the required test voltage, the following treatment will increase its insulating properties: A tank or a clean barrel makes a good filter for treating oil. A barrel with an outlet valve may be used by placing a very small mesh strainer over the valve outlet, then put six inches of very dry of baked sand in the bottom of the barrel and then six inches of unslacked lime and alternate with sand and lime until there are three layers of each. On the top layer place another small mesh screen or cloth and then a layer of dry straw and let the oil filter through all and it will be found that good clean oil with high insulating properties will be obtained from most any transil oil. A deposit usually forms in the bottom of the oil containers and whenever this is noticed it is well to remove the oil and filter it out.

What has been said of oil for transformers applies to oil used with all electrical apparatus where transil oil is used to break arcs or for insulating qualities as in the case of auto-starters, compensators, induction-regulators, arc-light regulators, etc.

When no means are available for testing oil by the voltage test a rough method is to place a sample of the oil in a bottle and let it stand for an hour or so and if there is any water present it will drop to the bottom and if any water is noticed the oil should be treated.

Terminals on Transformers

All transformers have two windings that are called the primary and secondary and each winding is usually made up of two coils. There are usually two leads brought out through the case at each of the front corners, these are the low voltage or secondary terminals of the winding, while at the back corners other smaller wires which are the high voltage terminals or the primary terminals are brought through the case.

Nearly all older types of small capacity transformers have terminal blocks located on the top of the coils and core inside the case, but this practice is fast being discontinued on account of insulation breakdowns, caused by lightning. Small transformers are nearly always designed to operate on different voltages, both primary and secondary; for an example, each primary coil may be wound for 1,100 volts, which would mean if the oils were connected in series that this same transformer could be operated from a 2,200-volt primary circuit.

From observation it will be noticed that there are usually but two wires from the primary side of the transformer brought out to the outside, and the student will remember that if ever the occasion calls for a change in the primary connections it must be done on the inside of the case.

In nearly all small transformers, there are four leads brought out through the case from the secondary windings, and if it is required to operate the transformer on different voltages the connection changes are made on the outside. For an example: Suppose that each of the secondary coils were wound for 110 volts, this would mean that the two coils were to operate in parallel on this voltage while if 220 volts was desired from the same transformer, with the same primary voltage, the two coils could be connected in series. As shown in Fig. No. 2, the leads, after leaving the coils, are crossed over so that one wire from each coil is brought out near the other. It is standard practice with all manufacturers to do this, and these two wires that lay so near together are of the same polarity, thus if a transformer, as shown by diagram in Fig. No. 2, was to operate on 110 volts, the two leads A and B at the right of the diagram would be connected together and likewise with those at the left marked X and Y.

Now by referring to the same diagram and assuming that this transformer was wound for 220 or 110 volts on the secondary side, to obtain these voltages we would make all the connections as follows: numbering the leads from left to right 1, 2, 3 and 4, 110 volts would be obtained by connecting 1 and 2 together and 3 and 4 together, but if we wished 220 volts we could connect 2 and 3 together, then 1 and 4 would have a difference of potential of 220 volts. The student who is not familiar with transformers will remember that not all transformers are connected this way but a safe rule to follow is to read the name plate which always specifies the primary and secondary voltages and if only one voltage is specified for each side they are the only ones obtainable, but if there are two or three for each side then these instructions may be followed.

Insulation

Insulation is a very important part of the transformer. As the copper and steel change but little with age and show practically no deterioration, it is evident that the insulating materials, being made of fabrics and paper, will be the first to cause trouble. The following points should be considered in insulating a transformer:

1—Each turn of wire should be insulated from all others by the cotton covering or enamel.
2—Each layer of wire composing the coils should be insulated from all other layers by japanned fibrous material or parchment paper.
3—Each coil should be separated from the others by fibrous material and entirely encased in several windings or varnished cambric; also there should be oil ducts between the primary and secondary coils so that the possibility of the primary coming in contact with the secondary is reduced to a minimum.
4—Each place where the coils and core come in contact should have special horn fibre placed between them.
5—All windings should, therefore, be insulated from the case, core and earth so that there will be a high factor of safety and as little leakage as possible.

All insulation used in building up a transformer should be tested with a voltage several times that with which it is to be used, and then impregnated with oil. To define transformer insulation in few words would be to say that it should receive first attention at all times.

Bushings

Where the wires pass from the inside to the outside of the case there must be some kind of insulating bushings. These are generally nothing more than a porcelain tube, filled with an insulating compound where the voltage is low, but where very high voltages are used, special outlets made of porcelain or other insulating material are used, these in turn being held in place by means of a fibrous board which also has high insulating qualities. The lead is then taped with several layers of varnished cambric and passed through the porcelain bushing.

One of the special terminals and bushings made by the General Electric Company is shown in Fig. 3. This company manufactures another type of bushing filled with transformer oil which has given remarkable success.

Transformers with Condenser Terminals

With voltages from 60,000 and up, terminals and bushings of the condenser types are often used. These terminals consist of a conducting rod surrounded by a number of concentric condensers of predetermined electrostatic capacity, arranged so that in effect they are connected electrically in series. The terminal is tapered towards the ends in steps, one step at the end of each metal layer. By this arrangement of metal cylinders, the potential difference between them is fixed by the design and, hence may be kept within the limit of puncture strength of the insulation. Moreover, as the edges of each metal layer extend to the edges of the cylinder of insulation immediately surrounding it, the potential gradient along the surface is practically uniform. The voltage stresses are distributed throughout the material equally and not concentrated at the surface. It is also free from corona when it passes through the case.

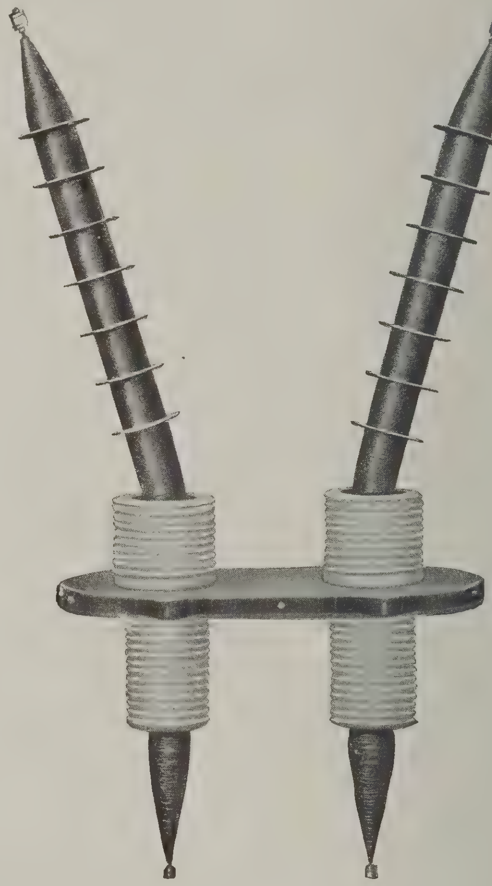

Fig. 3. Special Bushings for High Potential Transformers

Very few air cooled transformers require bushings as the connections are made from the underside directly to the terminal board which is provided with each transformer.

Alternating Currents

Williard Doud*

Single-Phase Motors

XI

As one of the principal uses of alternating current is for the operation of motors, it might be of considerable interest to discuss briefly the elementary principles which are involved in the design of various types of alternating current motors, both single and polyphase.

Alternating current motors generally are composed of two elements, the primary, which is usually stationary and sometimes called the stator, and the secondary, or rotating element, which is usually called the rotor.

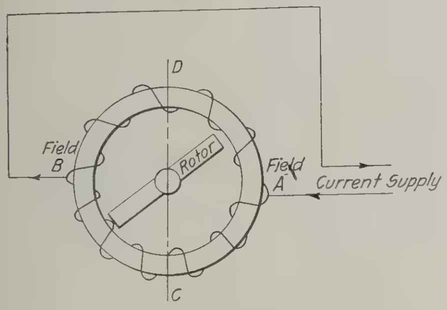

Fig. 1—An Alternating Motor of the Simplest Type. Such a Motor is Not Self-Starting.

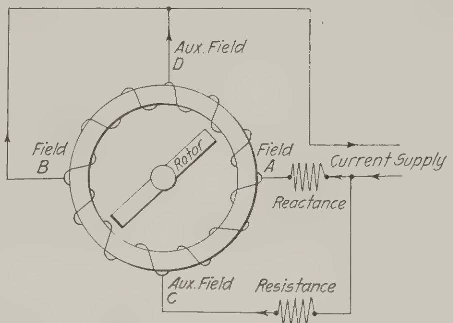

Fig. 2—A Single-Phase Induction Motor Started by the Split-Phase Method.

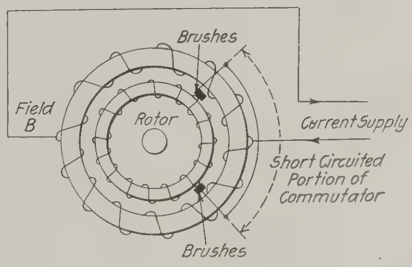

Fig. 3—One form of Repulsion Motor which is Started Like a Direct-Current Series Motor.

Single phase motors are generally of the induction or commutator type, while polyphase motors are usually of the induction type for ordinary service. The synchronous motor is in effect an alternating current generator in that the construction is practically the same and a separate source of direct current field excitation is required for its operation.

It has been stated in one of the earlier installments of this series that a single phase motor is not self-starting unless provided with some form of special starting device. This is exactly the case, unless some means is introduced to bring the rotating element up to speed. When a single phase motor is once started it will continue to operate from a single phase source of supply. It is also true that a simple single phase motor will operate in either direction equally well when once started.

Fig. 1 shows a diagram of an alternating current single phase motor of the simplest type. This motor is not self-starting for the reason that if a source of alternating current is connected to the terminals A and B, the portions of the ring on each side of the vertical line would become N and S poles with every reversal of the current. This condition would have no effect on the rotor, as its polarity would change with the polarity of the fields.

Another method of explaining the non-starting characteristics of the single phase motor is to assume that the current supplied to the motor produces two equal magnetic forces which revolve around the space between the rotor and stator at synchronous speed in opposite directions and, being equal and opposing, prevent the condition necessary for rotation, namely, one force in excess of another, and of sufficient strength to overcome its effects.

Perhaps the most common method of starting single phase induction rotors is to provide an arrangement which distorts or splits the phase of the current supplied and thus produce the conditions necessary for starting.

Fig. 2 is similar to Fig. 1, except that a source of current is supplied to the ring at two points, C and D, located midway between the terminals A and B. With the current supplied to terminals C and D, differing in phase from that supplied to A and B by a quarter period, the poles A and B will travel about the ring in the direction A C B D and the rotor will be dragged around in the same direction by the changes in the field.

In the split phase method of starting the current at C and D, is taken from the same source of supply as that furnished to terminals A and B, the distortion of phase being effected by proper reactance effect placed in the supply to A and B and a non-induction resistance in the supply to C and D. The poles A and B may be termed the main winding and the poles C and D the auxiliary winding, the latter being usually much smaller than the former and arranged to be cut off after the rotor had reached its full speed condition.

Proper proportioning of the reactance and resistance mentioned above produces what may be termed an elliptical revolving field, the displacement of the phases being the difference between the major and minor axes of the ellipse.

While the split phase method of starting single phase motors was the first means to be used, certain inherent characteristics rendered its operation not entirely satisfactory and it has been replaced by what is commonly known as the repulsion motor.

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*Consulting Engineer, Chicago, Ill.

If an ordinary direct current motor is provided with laminated field magnets and the field magnets excited by a source of alternating current supply, currents will be induced in the armature winding, provided the brushes are set at the proper angle, which is 45° from the correct direct current position for a two-pole machine.

The induced currents in the armature will be acted upon by the alternating field so as to produce the torque necessary to rotate the armatures. If the rotor is operated as a direct current motor while starting, and is provided with an arrangement by which the commutator bars are short circuited when up to speed, we have what is in effect the repulsion single phase rotor, perhaps the most satisfactory form of single phase motor yet devised. It will be noted that the short circuiting effect on the commutator transforms the motor when operating into an induction motor.

There are a great many methods in use for the starting of single phase motors, but practically all are various modifications or combinations of the split phase and the repulsion methods.

Any polyphase motor will operate on single phase current when once brought up to rated speed, but with a reduction in capacity of about 40 per cent.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 49

The Ampere Hour Meter

In our lesson No. 26, March, 1914, we described the resister type of ampere hour meter such as is used in controlling the battery charge in connection with the axle generator or head end systems. The principles of operation of the meter and its general construction were fully discussed at that time and will not be repeated here, the purpose of this lesson being rather to discuss some of the recent improvements in the ampere hour meter and the problem of its proper maintenance and repair.

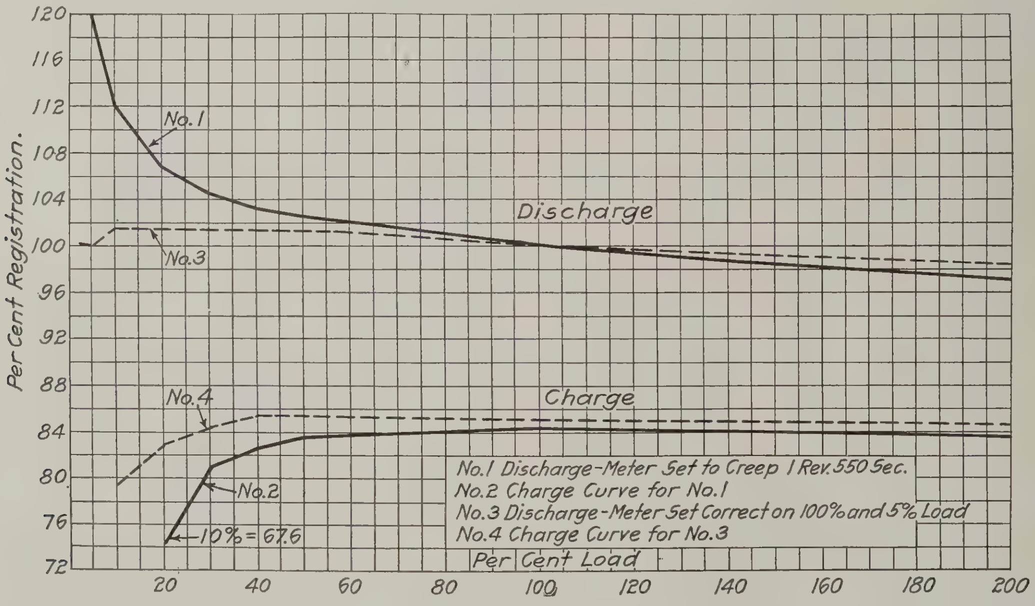

Fig. 250. Diagram Showing Meter Registration at Various Rates of Charge and Discharge With and Without the Thermo-Couple Feature. The Dotted Lines Show the Operation of the Meter Without a Thermo-Couple While the Solid Lines Show the Operation With the Thermo-Couple.

Thermo-Couple Feature

Probably the most important recent development in the ampere hour meter is found in the use of the thermo-couple for making the meter extremely accurate on light loads, causing it to register the discharge current of even one or two lamps. In fact, the thermo-couple adjustment may be set so as to make the meter actually creep on open circuit, thereby registering a slow discharge on the meter even though all lamp circuits be open. Every battery loses a certain amount of its capacity on standing due to local action, grounds, etc., and the creeping effect of the meter can be set so as to approximately equal the discharge while standing on open circuit and thereby automatically keep the meter in step with the battery so that it will at all times register the true ampere hour capacity remaining in the battery.

The action of the thermo-couple depends on the well-known principle that when two unlike metals are welded together and heat applied to the joint a potential is generated by the action of the heat on the joint, then when the cold ends of the welded piece are connected to an electrical circuit a current will flow just in the same manner as if the thermo-couple had been a storage battery or a generator. This thermo-couple, as employed in the ampere hour meter, is a tiny affair, but has sufficient power to circulate a maximum current of about ½ of an ampere through the meter. The terminals of the thermo-couple are connected directly across the current terminals of the meter, so that the thermo-couple is virtually short circuited by the meter, except that an adjustable resistance R, Fig. 251, is in series to set the meter as desired on light load. The voltage developed, however, is extremely feeble and sufficient only to force a small current to flow as stated above. The result of using the thermo-couple is that it causes the meter to creep in a discharge direction at the rate of about ⅙ of an ampere hour per hour, for a 40 ampere meter.

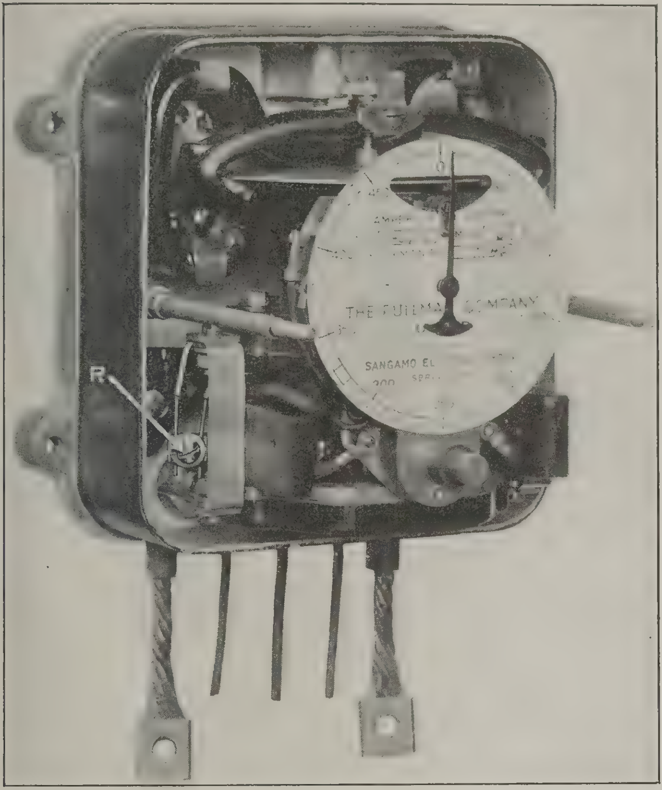

Fig. 251. Meter With Case Removed to Show Thermo-Couple Slide Wire Adjustment "R."

The heat is applied to the joint of the thermo-couple by means of the small electric heating coil *A*, Fig. 252, which is wound around the joint of the two metals. Current for operating this little heating coil is taken either from the battery terminals direct or from the outside of the main lamp switch, as desired. In the first case the meter would creep all the time, and in the latter would creep only when the lights are on, the current itself being, of course, recorded on the ampere hour meter. Inasmuch as the battery leakage goes on all the time, it would seem proper that the meter be set to creep all the time to compensate for it.

Operation with the Thermo-Couple

It is interesting to note the practical results obtained by the using of this thermo-couple. They are shown fairly well in the accompanying curves, which give the per cent of registration for the various rates of charge and discharge. It will be noted that the meter is adjusted to record 100 per cent correct at full load discharge, and will record but 85 per cent of the true ampere hours when charging at the full load rating of the meter. The rating of the meter is usually given both on the dial and on the main shunt on the back of the meter. This difference between per cent registration on charge and that on discharge can, of course, be varied at the will of the operator by simply making proper adjustment in the variable resistor.

The dotted lines for charge and discharge show the operation of the meter when no thermo-couple is used, while the solid lines show its operation with the thermo-couple feature. It will be noticed that on light load discharges the per cent registration of the meter with the thermo-couple attachment rises considerably, being 120 per cent at 5 per cent load. In other words, with a 3 ampere current flowing through a 60 ampere meter, the meter would actually record at the same rate as if the 3.6 amperes were flowing through the meter without the thermo-couple.

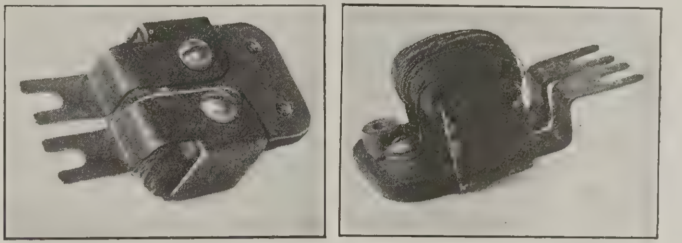

Fig. 252. Two Views of the Thermo-Couple. The View at the Left Shows the Forked Ends of the Two Metal Strips Which Are Connected to Binding Posts in the Meter. The View on the Right Shows the Small Coil Wound Around the Junction of the Two Strips of Two Different Kinds of Metal.

The thermo-couple then contributes about 6/10 of an ampere, and this current, even with all lamp circuits open, will cause the meter to record a discharge of about ⅙ of an ampere hour per hour as above mentioned. There is a slide wire adjustment feature which makes it possible to increase or decrease the creeping, and this is shown at *R*, Fig. 251; raising the slider increases the creeping and *vice versa*.

It will be noticed from the curves of Fig. 250 that when the current is flowing in a charging direction the thermo-couple opposes the flow of the current through the meter and causes it to register at a slightly slower speed; this, at full load, being about 84 per cent instead of 85 per cent as without the thermo-couple. At the lower charging rates, on the other hand, the meter exerts a more powerful influence just as it did on low discharge rates, but in the opposite direction causing it to record only 75 per cent of the true ampere hours charge with ⅕ rated load and but 67.6 per cent of true ampere hours at 1/10 load.

The meter will record a fairly large percentage of the low rate charge, such as the battery receives when operated near its floating potential. The battery will then automatically be given a slight overcharge in excess of the 15 per cent provided for by the variable element of the meter. This, however, in actual service will be small in number of ampere hours overcharge, and instead of working any injury to the battery will actually be beneficial since it will serve as an additional check on the operation of the meter and keep the battery in a full state of charge.

Quick Break Contact

The quick break contact, which has recently been developed for car lighting type ampere hour meters, is another feature worthy of note. The meter dial hand, instead of simply making a butt contact as it comes around to the zero point, engages a dog which is pivotted and bears against a spring carrying a platinum contact causing it to make contact with similar platinum point above thus closing control circuit.

After the dial contact has been made and battery charging discontinued, the meter is no longer driven in a charging direction. Accordingly, the contact remains closed until the battery has discharged so that the meter hand moves back about 1/12 the full dial revolution, at which time the meter dial contact is opened instantaneously.

Meter Troubles

Some of the earlier types of meters gave trouble, due to the softening of the shellac-mica composition of the armature chamber under the excessive heat in some car lighting lamp regulator lockers. This softening and warping of the armature chamber caused the meter shaft to get out of alinement and the armature disc to bind. This trouble has been overcome by molding the armature chamber of bakelite or condensite. This material does not soften even under temperature as high as 400 degrees Fahrenheit. The meter sometimes gives trouble from other causes, and it will be interesting to now consider how these may be located and rectified.

The testing and maintenance of the ampere hour meter will be covered in the next article.

The Railroad Electricians' Club

February Meeting New York Car Lighting Association

The Edison Storage Battery in Railway Car Lighting

By Harold H. Smith*

The conditions of train lighting service are among the most favorable to which a storage battery can be subjected. The rates of charge and discharge are predetermined and fixed by the use of various forms of regulators and controllers, and the batteries are usually cared for under a carefully systematized plan. All of this tends to make possible a routine comprising the conditions recommended by the battery manufacturers as productive of the most favorable results.

The service requires of the battery that it be reliable—always ready when called upon to do its work—constant in its characteristics and requiring the minimum of special treatment in order that it may readily adapt itself to the routine necessary in this work. Given, therefore, a battery that is adaptable to routine, we find that the service which imposes the most nearly ideal conditions for that battery is that which is routine. Economy is also a matter of supreme importance and is one that is given perhaps more earnest and detailed consideration by the railroads than by any other class of battery users.

Battery Construction

The structural features of the battery are distinctly different from those of other storage batteries and it is hardly necessary, here, to describe them. A brief review, however, of the salient features may serve to inform some and refresh the memory of others.

Externally the cell appears as a sealed metallic container with corrugated sides. Through the top the tapered poles project and between them there is a single opening which permits of filling with water or solution as required. The hinged cover to this opening carries a loosely hung spherical hard-rubber segment, which seats against the mouth of the vent and prevents ingress of air or other foreign matter. At the same time it permits the cell gases to escape and acts as a separator for the moisture held in suspension by the escaping gases. The poles pass through stuffing boxes, which prevent the passage of gas or liquid. The body of the cell is coated with a black insulating and protecting compound. The active elements of the cell are nickel and iron and the electrolyte is potassium hydrate in solution with a small quantity of lithium hydrate.

The positive plate consists of spiral tubes made from perforated, nickel-plated steel ribbon. These are filled with alternate layers of green nickel hydrate and metallic nickel flake—about 300 layers of each. Each tube is strengthened by eight seamless steel rings, which circumscribe it equidistantly along its length. Both ends of the tubes are flattened, forming terminals for clamping, under heavy hydraulic pressure, into the nickel-plated steel grid.

The negative plate consists of flat pockets, likewise of perforated steel, nickel-plated, which are filled with finely powdered metallic iron. The nickeled steel grid is punched to receive the filled pockets and then the whole is subjected to a pressure of many tons. This pressing operation compacts the active material, corrugates the pocket surfaces and squeezes their edges into intimate contact with the grid. Each group of plates is then mounted on a horizontal rod attached perpendicularly to the lower end of one of the poles, and they are fastened in place by steel nuts and washers. For train lighting the A8-H cell is in most general use. The letter "A" designates the size of plates, the numeral indicates the number of positive plates, the negative being always one in excess, and the letter "H" signifies the high can previously mentioned as having been especially designed for this service. The finished cells are mounted three each in trays conforming to the standard dimensions long ago established for train lighting batteries. This necessitates the batteries being assembled with unnecessarily large spacing between the cells. Some railroads have found it profitable to depart from the standard practice and take advantage of this extra space by using smaller compartments, thus reducing the weight and cost.

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*Electrical Engineer, Edison Storage Battery Co.

The weight of a standard tray of three A8-H cells is in the neighborhood of 100 pounds, which may be readily handled by one man. The battery for 30-volt equipments consists of 8 trays of 3 cells each and one similar tray containing only one cell.

Effect of Temperature

The alkaline battery has been the subject of much persistent criticism, because of its alleged susceptibility to temperature variations. I know that a number of the gentlemen present have satisfactorily disposed of this criticism out of their own experience, and it is useless to mention the matter to them. There are, however, some, doubtless, who still have "alkaline battery" and "temperature effect" crowded into the same compartment of memory's storehouse, so that every time one is brought forth the other comes also.

Strangely enough, little is said about high temperatures and yet it is high temperatures that is really the more temperature will naturally cause the electrolyte to evaporate more rapidly than normally, especially if the high serious, because it may effect permanent injury. High temperature is caused by high charging rates. If the solution then gets below the plate tops the heating effect is aggravated through increased current density at the surfaces immersed and so, unless conditions are carefully watched when undue heating commences, it may rapidly get so far as to cause permanent injury. For short infrequent periods the Edison battery will withstand severe heating better than other types, and it is for this reason that numerous batteries have come through destructive fires with no harm done except to the rubber parts, which may be replaced at small expense. And also why the battery survives sustained short circuits without harmful effect. In train lighting, injurious temperatures are seldom met with, for the rates are almost never very high and ventilation is usually sufficiently provided in warm weather. On Southern roads it has been observed that where conditions are kept right the battery is seldom more than 5 degrees warmer than the surrounding air. The car lighting equipment of the Panama railroad includes none but Edison batteries.

And again we must discuss conditions when it comes to a consideration of low temperatures. In the laboratory it can unquestionably be shown that the alkaline battery is somewhat more susceptible to the effect of cold than are others. This is partly because of inherent characteristics, partly because of the metallic containers and partly because of the greater cell spacing. In service it has been shown beyond all question of doubt that cold can absoutely be nullified by simple, inexpensive modifications of compartment design. The battery is self-warming—still air is a good heat insulator—a battery surrounded by still air keeps sufficiently warm for satisfactory operation. In a test made a year or two ago, a train lighting battery was housed in a tight metal compartment (except for barely necessary ventilation to permit gases to escape), but with wind space all around the compartment itself. The test was made over a period of six weeks of the most severe cold weather. During this period there was a stretch of 11 days during which the temperature averaged 32 below. A recording thermometer indicated that within the compartment the temperature had reached a minimum of 8 below, and yet throughout, the operation of the lights had been completely satisfactory.

In January, 1914, Canada experienced the severest cold recorded for 38 years, and yet 23 Edison-equipped cars on the Canadian Pacific Railway gave service that completely dispelled all fears on this score. Since that time their Edison equipment has been doubled and three other Canadian railroads have adopted the Edison battery.

The ruggedness of the Edison battery becomes evident upon considering its mechanical features. It has been proven in the laboratory by allowing a cell to fall free half an inch one and three-quarter million times onto a solid plank of hard wood without injury to the cell. This is not unimportant in car lighting service where there are occasional wrecks and frequent jolts due to coupling cars.

Chemical Impurities

Chemical impurities are more harmful in an electrochemical combination, such as a battery, than in any other. This is because of the action of the current. Under the influence of the electric current many inactive reagents become active, and when the current is periodically reversed the chemical action of many impurities is repeated at each reversal. It, therefore, becomes evident that time is an important factor, as well as quantity. A small quantity of sulphuric acid, for example, in an Edison cell will do no harm if the electrolyte be quickly poured out, the cell carefully rinsed and refilled with fresh solution. But if the small amount be allowed to remain and the cell is kept in operation, the corrosive effect will sooner or later accomplish its evil work. It is for this reason that the use of pure distilled water for flushing must be rigidly insisted upon. It is the only kind of water whose constancy or purity can be depended upon. One reason for using the Edison battery is its long life—hence it is especially important to observe the strictest standards of purity, for the time element is great. This is particularly true in train lighting service, for even the partial removal of impurities that takes place when the solution is changed occurs at comparatively infrequent intervals.

Renewal of Solution

Solution renewal is necessary when the electrolyte has become so weakened in service, that, after a full charge, with the solution level at the proper height, the specific gravity is below the limit prescribed in the battery instructions. Experience has demonstrated that this should occur ordinarily in from 18 months to 2 years.

Some railroad men have, however, disregarded the instructions of the Edison Company about changing the electrolyte every two years and have left the electrolyte in the battery for three or four years with no apparent ill effects. It may be, therefore, that the Edison Company was too conservative on this point. In any event, a method has now been found by which the old electrolytes may be rejuvenated, and the Edison Company will be glad to receive such old electrolyte, for which a substantial allowance will be made.

Flushing the Battery

Flushing with distilled water is necessary from time to time to make up for the loss of water that occurs through gasing while the battery is on charge. It should not be required in ordinary car lighting service oftener than once every two or three weeks. If it is, it is an indication that something is wrong—probably either overheating, overcharging, or both—and the trouble should be found and corrected.

One practice should especially be warned against, and that is the filling of cells with electrolyte when the solution is found to be unusually low. If it has become low by neglect, the added solution will increase the density to a point where the plates are likely to be subjected to dangerous strains. Water should always be used unless it is positively and beyond doubt known that the solution became low through spilling.

In car lighting service, where the battery is not constantly under the care of one man, it is especially necessary to eliminate danger to the apparatus or to the continuity of operation by explicit rules, like the above, that "play safe." Another variable that enters into the operation of storage batteries, particularly under conditions of continually changing attendance, is the state of charge or discharge at any particular time. A driver of a storage battery truck or railway car who knows his car can make a pretty good guess by what he calls the "feel" of it. His judgment is contingent upon his running day after day the same vehicle with the same battery. In car lighting no such condition exists and it is therefore highly desirable from the standpoint of service and economy to provide positive means of knowing just what net amount of current has gone to or from the battery.

Ampere hour meters are now available which provide this information at all times under just such intermittent charging and discharging as it met with in railway lighting, taking full account of the ampere hour efficiency of the battery. That the railroads are adopting the ampere hour meter is a good sign.

Insulating the Trays

I have previously mentioned that Edison cells and trays are coated with a protective insulating paint. It is hard to understand what a problem it has been to find a paint that meets all the required conditions of adhesiveness, non-brittleness, elasticity and alkali-resisting ability. The matter has been gone into with great care and from time to time it has been possible to improve upon the product employed in one direction or another without sacrificing some other quality. It is believed that the compound now in use comes very close to having all the desired properties. Several commercial paints, however, have been approved for this purpose, as it is often convenient or desirable for the user to purchase as he chooses. The paint is, of course, for the purpose of protecting the cells from grounds and electrolysis.

A rather recent development, also along this same line, is the adoption of a tray which provides support for each cell on hard rubber at four or eight points, according to the size of the cell, and leaving the bottom entirely free. Metallic bosses of ample proportions, spot-welded to the sides of the can, fit into recessed hard rubber buttons in corresponding positions in the tray slats, and these are the only points at which the cells are in contact with anything except the necessary electrical connectors. The trays may have bottoms or not, according to individual requirements, but in any case the cells will not touch or be supported at the bottom.

Now, a word as to the service. The straight storage and axle generator systems are the principal ones at present in use and of the two the latter is the more popular.

Straight Storage System

The straight storage system is ideal from the battery point of view, but usually is inconvenient from an operating standpoint. With it full charges and discharges are possible and full normal charge rates can be maintained. At the present time there are in the neighborhood of 40,000 Edison cells in straight storage service. The balance, with the exception of a few in head-end service, are used in connection with axle generator systems.

Axle Generator System

The latter system possesses many advantages, and evidently, in the opinion of the majority of operating men, they overbalance the contending advantages of the other systems. There is every reason to believe that in time the characteristics of the straight storage method will be so nearly approached as to leave no choice as far as battery conditions are concerned. The trend is in that direction. It is not improbable that a scheme will be successfully worked out whereby the advantages of constant potential charging will be available with the axle machine.

It has been found necessary to recommend charging at not less than normal rate. At first two-thirds normal was the prescribed minimum, but that had to be changed for the following reason: In automobile work charging is done usually at night and it is customary for the garage man to stop in his other duties every half hour or so—if he thinks of it—inspect the ammeters in charging circuits and adjust the rheostats. The current between readings, of course, always falls below the standard to which it was previously set, and if this standard is two-thirds normal, the average is obviously considerably less. This explains why two-thirds normal rate worked in the laboratory and always appeared to fail in service. As the same conditions are prone to exist in all kinds of service, the policy of always insisting upon at least normal rate was adopted. This is a little inside information which you gentlemen, as engineers, are welcome to—but you are urged not to forget the explanation that goes with it.

Battery Inspection

The Edison battery is a favorite with those whose desire it is to be battery inspection experts without going to the trouble of developing a good memory. There are just three things to remember:

1st: The solution must be kept at a proper level.

2nd. The compartment and battery must be kept clean and dry.

3rd: The electrolyte must be removed when the specific gravity is low.

This does not mean, however, that inspection should be done in any but the most painstaking and careful manner. Short inspections at frequent intervals are better than long ones made less often. Some roads have adopted, with gratifying results, the plan of inspecting for poor contacts, dirty cells, condition of compartment, etc., every time the battery is flushed, or—in other words—about every six weeks or so. It is my understanding that individual cell tests need not be made oftener than about once in six months. Thus, many a stitch is taken in time.

In service the battery has substantiated all claims that have been made for it. The first train-lighting sets were installed a little more than six years ago. One of the very earliest of these was in a battery house fire about two years ago and was returned to the factory for repairs, because most of the rubber parts had been more or less completely destroyed. After the repairing was completed (and it had consisted only of replacing the rubber parts), the battery was put on test and to a cell it tested well above rated capacity—this after four years of service and a fire! All the others of those early sets have evidently escaped fires and have equally well survived the rigors of continuous service.

In 1912 there were about 8,800 Edison cells in use for train lighting. To-day that service is employing about 100,000 cells, distributed among 80 per cent of the railroads of the country—some of which use them to the exclusion of other types. Practically all the cells that have been sold for this purpose are now in use, and the few that are not were injured in wrecks or through acknowledged abuse. Do not let me give the impression that none have been returned for repairs. Some have been repaired, but in the aggregate they amount to only one-tenth of one per cent of all the cells in the service. The trouble with these has been chiefly leaky cells, due partly to defective seam welds (and these are always repaired free) and partly to electrolysis, because of faulty inspection.

Questions on the Edison Battery

Answered by H. H. Smith at the February Meeting of the New York Electric Car Lighting Association

After Mr. Smith's instructive address, the subject was thrown open for discussion and numerous questions were brought up and answered.

Cause of Reverse Cells

Q. What is the cause of one or two cells in a battery being completely reversed?

A. Mr. Smith explained that all cells of the same type and rating do not always have exactly equal capacity. For this reason some cells having slightly less capacity than the others will be reversed when the battery is over discharged. The reason for this is that the voltage drops rapidly at the end of the discharge and goes below zero. In such cases simply leave these cells, which are reversed, in the battery and charge and discharge them until conditions are again normal.

Reversing the Plates

Q. Is it possible to reverse the positive and negative plates in such a case?

A. No, it is not because of the different material in the two plates, the positive being iron and the negative nickel.

Effect of Charging in Reverse Direction

Q. What will be the effect on an Edison battery of charging it in a reverse direction?

A. No ill effects whatever. Reverse charging simply decomposes the water into hydrogen and oxygen. Mr. Smith then mentioned several instances where Edison batteries were charged in a reverse direction for two or three days with no bad results whatever. In each case, when the battery was finally charged in the proper direction, full capacity, and, in fact, greater than rated capacity was obtained.

Voltage of Edison Batteries

Q. What are the limits of voltage when charging and discharging an Edison battery under normal conditions?

A. 1.5 to 1.8 volts on charge and 1.3 to 1.1 volts on discharge. In car lighting, the rated capacity is obtained when the voltage reaches 1.1 on discharge. Further discharge may go on with a resultant increase of capacity.

Ampere Hour Efficiency

Q. What is the ampere hour efficiency of an Edison train lighting battery?

A. Mr. Smith stated that the ampere hour efficiency of an Edison train lighting battery is considered 80 per cent under normal operating conditions, which means that an ampere hour meter, controlling the charge of such a battery, would be set to run 20 per cent slow on charge.

Harmful Impurities in Electrolytes

Q. What electrolyte impurities are considered the most harmful?

A. The electrolyte being alkaline, acids are the most dangerous impurities, as they neutralize the electrolyte. Copper, zinc, tin and practically any metal except iron and nickel will set up local action which is also undesirable.

Q. What should be done in case acid got into the electrolyte?

A. The best thing to do would be to throw the electrolyte away and put in fresh.

Leaving Battery in Discharged Condition

Q. What would be the result of leaving an Edison battery in a discharged condition?

A. Such treatment would result in no harm whatever; in fact, it is a little better to leave the battery in a discharged condition instead of a charged condition. Mr. Smith then related that a very kind letter had been received by the Edison Storage Battery Company from a friend in Denver who spends his winters in Florida. This gentleman had left his electric car in the garage during his absence and on his return was much surprised to find enough "juice" in the battery to run the car for two days.

Straightening a Bulged Can

Q. What is the best method of straightening a can which has been bulged by an internal explosion?

A. You can press the sides of the cells back in place. If, after doing so, it is found that the cell is dead, it means that the rubber separator is broken and the cell must be returned to the factory for a new can.

In answer to a question about the cause of the explosion, Mr. Smith explained that the plate, when exposed, due to low electrolyte, gets hot and explodes the gas with no harmful results other than bulging the can in some cases. If an explosion occurs, it takes place very suddenly in the space above the electrolyte and the can is, therefore, bulged only above the electrolyte level. In case the can is bulged all the way, from top to bottom, it will be found that the gas vent has been stopped, causing an excessive gas pressure inside the can.

Open Circuit Voltage

Q. Of what value is a voltage reading on open circuit?

A. No value whatever, as both charged and discharged cells give a similar reading to within a few hundredths of a volt.

Maximum Temperature

Q. What is considered the maximum allowable temperature of the electrolyte?

A. The temperature of the electrolyte should be kept below 115 degrees. It is found, however, that the temperature of the electrolyte is very seldom more than five degrees above the surrounding air.

Importance of Keeping Cells Dry

Q. Why is it necessary to keep the cells of an Edison battery dry?

A. As the cans are not insulated from the electrolyte, they have a certain polarity which will cause current to flow from one cell to another, especially between those which are two or three cells apart. This leaking current will, of course, cause corrosion of the can.

When to Change the Electrolyte

Q. How can you tell when to change the electrolyte?

A. Mainly by a low specific gravity which should not be below 1.160, or by a loss of capacity.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

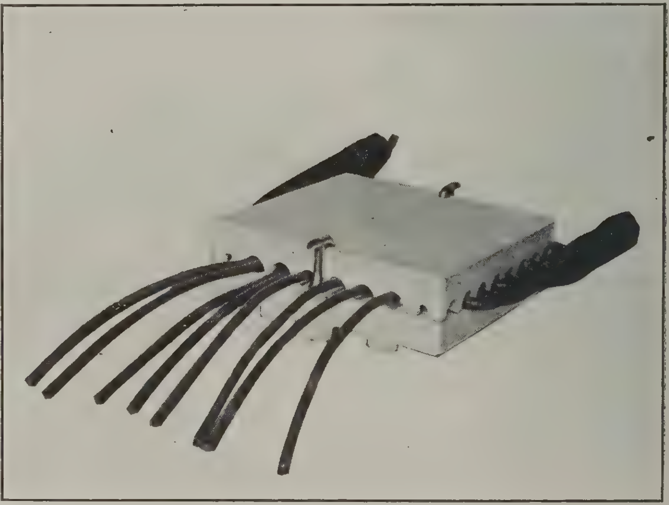
A New Car Wiring Connecting Block

In the following letter R. Hodgson describes a connecting block to be placed either in the panels between the deck sashes or in the junction boxes on the roof of the electric lighted cars so as to do away with soldered splices and thus facilitate the location and correction of grounds and other troubles. The illustrations show the appearance of this block and its application in modern car wiring. Mr. Hodgson, who is one of the patentees, wishes to state that the block will shortly be put on the market on a commercial basis, either by one of the railway supply houses or by the patentees themselves. In the meantime they will welcome a criticism of the block or suggestions for any changes in its construction that other car lighting men think desirable or necessary.—Editor.

To the Editor of the Railway Electrical Engineer:

Since steel cars have become standard there is no doubt but what many of the car lighting men are continually running up against the same trouble as I am. Generally this trouble consists of a ground on one side of a particular lamp or fan circuit when there is a ground on the opposite side of the battery circuit at the same time. This will invariably blow one of the fifteen ampere circuit fuses, thus causing a failure on that particular circuit. Now, in this case, and in the majority of similar cases, the quickest way to remove the trouble is to clear the ground from the light circuit; of course the trouble can be removed temporarily by crossing wires and putting both grounds on one side of either line, but it has been my experience that it pays to clear the trouble and make permanent repairs.

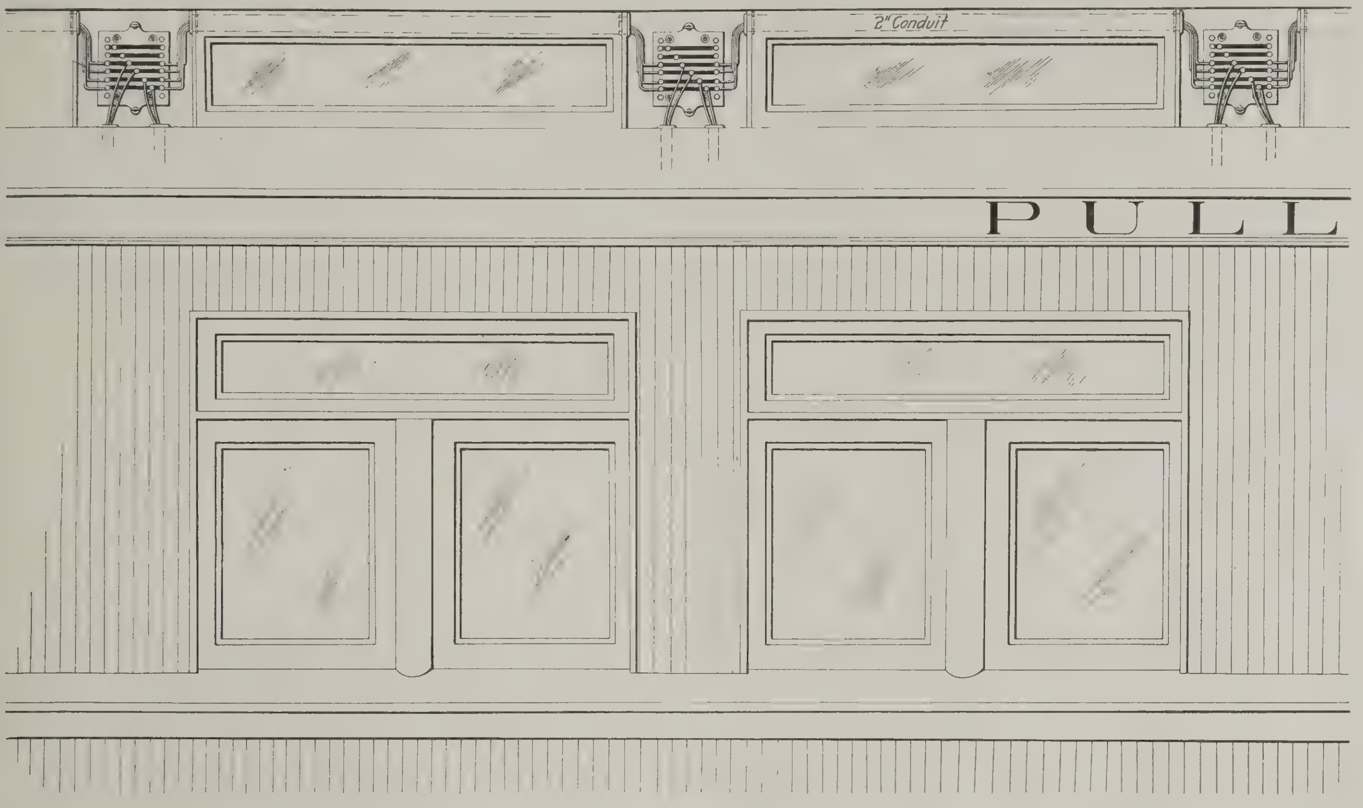
Now, if the old system of soldering and taping splices was in use on the cars, I would naturally have to go to about the center of the wiring and ring back to the switchboard until I found the correct circuit, then cut the wires and ring with a magneto to find which half of the circuit was grounded. After finding the right half I would possibly make four more cuts before the trouble was located, then I would have to splice all those cuts and solder and tape them again before the car was ready for service, and on a steel car you do not have to have many grounds before the wiring is all cuts and splices.



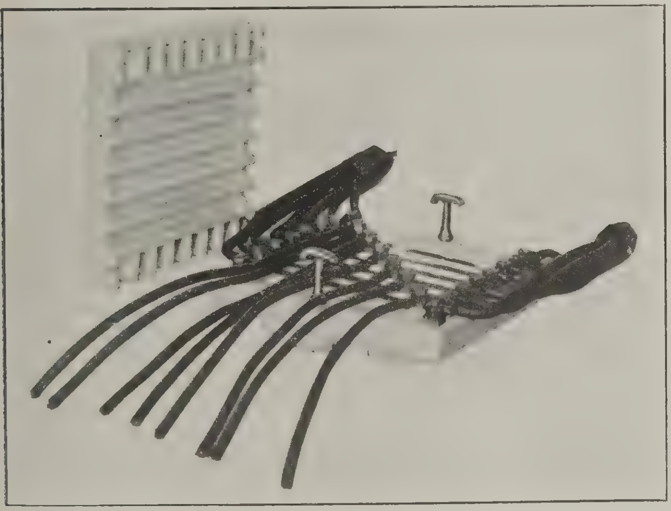
View of the Connecting Block Complete. The Two Brass Hooks Which Hold the Cover in Place Are Lifted Up Against a Coil Spring at Their Base and Turned to One Side When the Cover is to Be Removed.

On a steel car it is easy for a switch or socket to become either grounded or shorted or for a wire to chafe at a sharp bend and cause similar trouble, and I can recall cases of corroded splices which may have been caused by some district using plain cut muriatic acid for a soldering flux, probably because a standard soldering flux was not in stock.

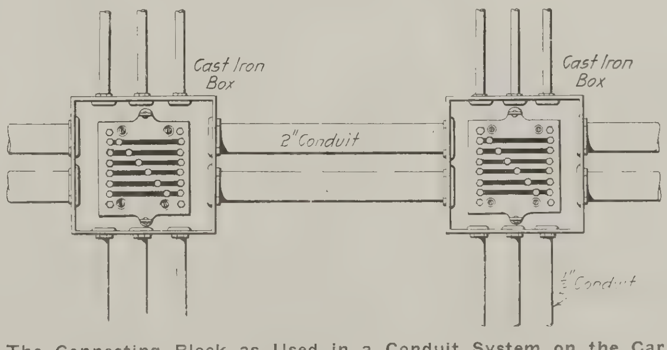
I have found open circuits caused through vibration of a splice which may not have happened if this splice had been soldered, but I have known of times when the car has been ordered to go out on its run in such a hurry that the splices have just been taped up, without soldering. Now on rush jobs, if the connecting block was installed it is not necessary to rush to the shops for torch and tape, etc.; pliers being all the tools that are necessary, and most of the boys carry them all the time. When clearing a circuit with the connecting block it is only necessary to disconnect the lock nut, then the other nut, to take off the washer, which is used to prevent the wire from spreading, to lift the circuit clear of the binding post, and the circuit is then all ready to work on. When looking into a junction box with this system installed you do not see a hopeless bunch of splices, but instead a neat connecting block, with every circuit marked on the cover.



Sketch Showing the Connecting Block Installed in the Panels Between the Deck Sashes

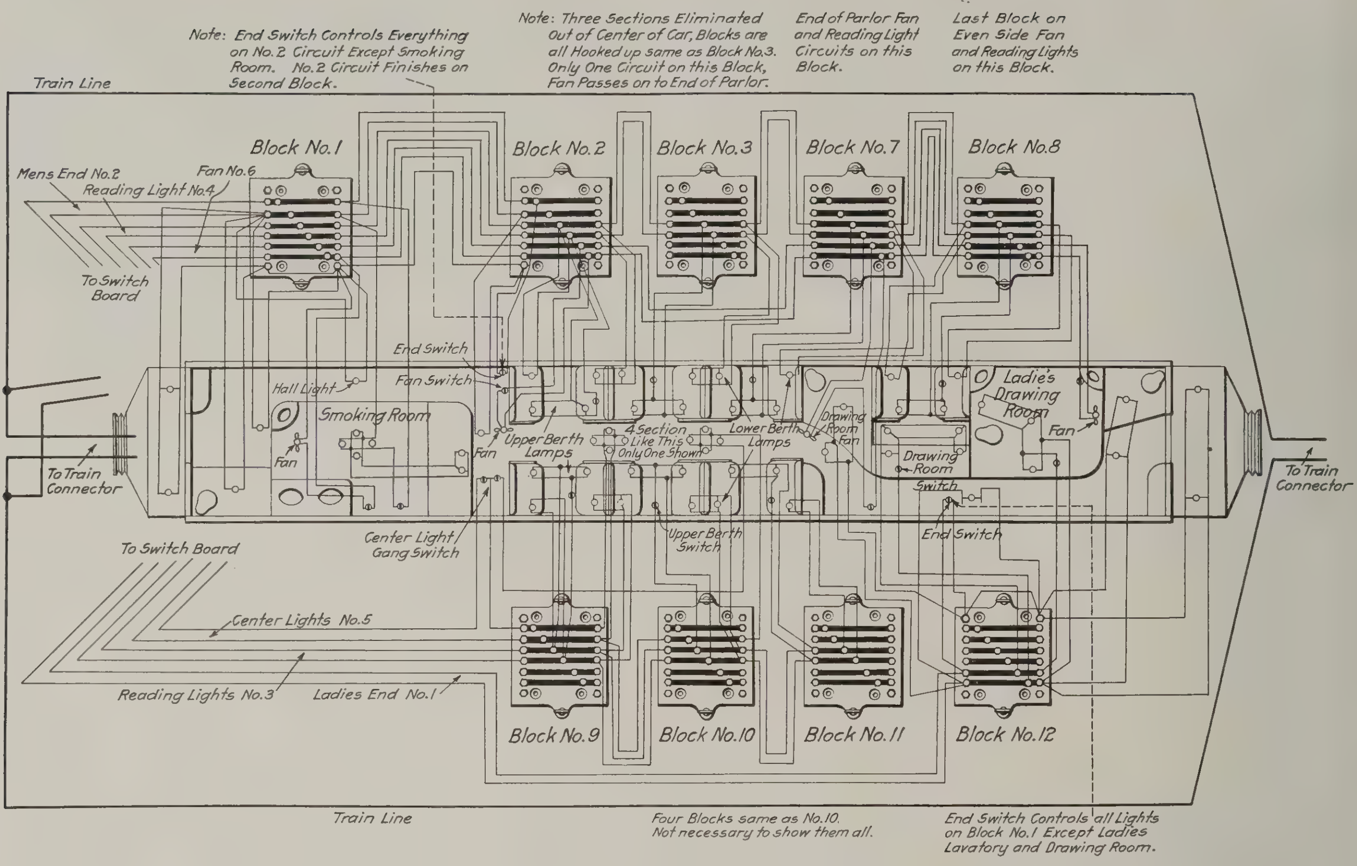


View of the Connecting Block with Cover Removed. Note the Lock-nuts on the Binding Posts and the Insulating Recesses in the Cover.



The Connecting Block as Used in a Conduit System on the Car Roof or Under the Floor

This block was not designed for dining cars and sleepers only, but can be used on any kind of coach where splices are used. It can be used in the conduit on the roof or under the eaves in the panels, and if the new system of wiring underneath the base of the fixtures is used, it can be installed there just as easy as any place; in fact, it can be adapted to any kind of car wiring. In the old system of wiring cars there was a number of short lengths of wire wasted, but with this system left-off short lengths are all used up. At the same time it is not necessary to


Note: End Switch Controls Everything on No. 2 Circuit Except Smoking Room. No. 2 Circuit Finishes on Second Block.
Note: Three Sections Eliminated Out of Center of Car, Blocks are all Hooked up same as Block No. 3. Only One Circuit on this Block, Fan Passes on to End of Parlor.
End of Parlor Fan and Reading Light Circuits on this Block.
Last Block on Even Side Fan and Reading Lights on this Block.
Train Line
Block No. 1
Block No. 2
Block No. 3
Block No. 7
Block No. 8
Mens End No. 2
Fan No. 6
Reading Light No. 4
To Switch Board
End Switch
Fan Switch
Hall Light
Smoking Room
Fan
To Train Connector
Upper Berth Lamps
4 Section Like This Only One Shown
Lower Berth Lamps
Drawing Room Fan
Ladie's Drawing Room
Fan
Drawing Room Switch
To Train Connector
To Switch Board
Center Light Gang Switch
Upper Berth Switch
End Switch
Center Lights No. 5
Reading Lights No. 3
Ladies End No. 1
Block No. 9
Block No. 10
Block No. 11
Block No. 12
Train Line
Four Blocks same as No. 10. Not necessary to show them all.
End Switch Controls all Lights on Block No. 1 Except Ladies Lavatory and Drawing Room.

Wiring Diagram of a Standard Pullman Car with the Connecting Blocks Used in the Panels Between the Deck-Sashes

use five or six pounds of tape to a car. Material saving is also made on solder and flux, and it is seldom necessary to refill the gasolene torches for soldering and the block can be installed just as quickly and cheaply as making splices.

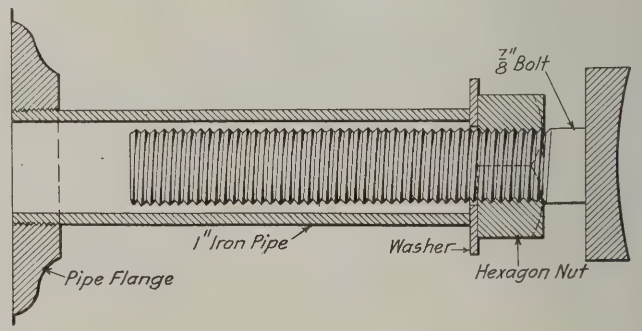
The illustrations show exactly how the block and cover look. Both are made of hard glazed porcelain, the buss bars are made of brass with three binding posts, the connection is made on the post by looping wire around and resting it on the collar. A washer is then placed over the wire to prevent it from spreading, then one nut is applied to bind the connection on the post and another nut is used to lock it. When this connection is properly tightened a good mechanical and electrical connection is made. Each binding post fits into its own insulated pocket in the underside of the cover, so there isn't any danger of short circuit if cinders get into the junction boxes. If this block was used as a standard on all cars it would greatly reduce the car lighting boys' troubles on foreign cars, because when climbing on the roof of a strange car they would know by the numbers on the cover of the block what circuit was in that box, which would save ringing all the wires back to the switchboard to find the grounded or shorted circuit.

The wiring diagram on this page shows two ends and one section of a standard Pullman car. Only the one section is shown because the others are wired exactly the same and for that reason it is not necessary to show them all. By inspecting this diagram it is seen that, when using this block, any car can be wired without making one splice in the switch loops, light wiring or fan circuits, except when applying fixtures.

R. Hodgson, 925 Ionia Ave., S.W.
Grand Rapids, Mich.

A Handy Axle Machine Jack

When giving a U. S. L. generator a thorough inspection a good deal of trouble is often experienced because it is sometimes hard to "kick" back the machine when loosening the belt. To overcome this difficulty a small jack, as shown in the illustration, will be quite a help. The screw part of the jack consists of a ⅞-in. bolt threaded close to the head, the head itself being filed out to a concave shape so as to fit the link irons. The standard is a nipple of one inch pipe with a floor flange for a base. By placing the jack between the link irons and the side irons, parallel to the tension rod and tightening the hexagon nut against the pipe any machine will be forced back the required amount. On account of its light weight the jack can easily be carried in the tool box and will also be found quite a help when applying foot bushings and changing link pins. This jack can, of course, be adapted to the other types of axle generators.



Ernest Zinzer, The Pullman Co., St. Louis, Mo.

Personal Mention

F. V. McGinness

Car lighting men will be interested to learn of the recent appointment of F. V. McGinness as manager of the railway department of the Edison Storage Battery Company.

Mr. McGinness is a graduate of Columbia University, having received the degree of electrical engineer, 1910. After leaving the university he was, for a short time, with the New York & New Jersey Telephone Company, and also with the New York & Queens Electric Light & Power Company at Long Island City, N. Y. In the latter connection he was occupied chiefly with computing distribution systems, although at this time he received some practical battery experience in connection with the stationary type batteries of the company.

F. V. McGinness

He became connected with the Edison forces in 1911, being then engaged in experimental work in Mr. Edison's laboratory. At this time he also received a thorough training in the manufacture of the Edison battery.

Mr. McGinness has been engaged in railway storage battery work for the past four years, during which time he has made a wide acquaintance among railroad car lighting and signal men, who will be interested to learn of his advancement. Previous to his appointment as manager of the railway department he was assistant manager of this department, and while in this position did much to place the Edison battery in the strong position in the railroad field that it holds today.

Mr. McGinness will have entire charge of the railroad end of the Edison Storage Battery business and will have his headquarters at the Edison factory at Orange, N. J., but he, of course, will find time to call on the various railway electrical engineers throughout the country in connection with his new work.

R. L. Wilson

Mr. R. L. Wilson, Manager of the Railway Division of the Westinghouse Electric & Manufacturing Company, East Pittsburgh works, has been appointed Assistant General Superintendent, looking directly after trades apprentices, employment, working conditions and other matters of a similar nature.

Mr. Wilson was born in Shelbyville, Ind., and is a graduate of Rose Polytechnic Institute of that state. He entered the employ of the Westinghouse Electric & Manufacturing Co., in 1893, as a student draftsman, and subsequently became inspector, engineer of construction, and later superintendent of construction, at one time being in charge of erection work in the New York district. Later Mr. Wilson was made superintendent of the Railway Division, which position he continues to hold.

He is chairman of the joint committee appointed by the company and the employees for the settlement of differences in opinion arising between the employees and the company, and is also trustee of the Veteran Employees' Association of the Westinghouse Electric Company.

New Books of Interest to Railway Electrical Engineers

Electric Railway Engineering. Second edition. By Francis Harding, E.E., Professor, Electrical Engineering; Director Electrical Laboratories, Purdue University, assisted by Russell C. Ewing, E.E., M.E., Assistant Professor Electrical Engineering, Purdue University. 416 pages, 190 illustrations, 6½ in. by 9¼ in. Bound in cloth. Published by the McGraw-Hill Book Company, Inc., 239 West 39th street, New York. Price, $3.

This book should be of value to students in technical universities who wish to specialize in the subject of electrical railway engineering and to those who understand the fundamental principles of electrical engineering and are interested in their application to electric railway practice.

While it is planned primarily for a senior elective course in a technical university, it does not involve higher mathematics, and should, therefore, be easily understood by the undergraduate reader; the volume does not purport to present any great amount of new material or principles, but it does gather in convenient form present-day theory and practice in all important branches of the electric railway engineering. Frequent quotations from technical papers and publications in engineering periodicals are given, because it is only from the authorities and specialists in particular phases and this volume contains a summary of the best that has been written of the profession that the most valuable information can be obtained.

Although but one entirely new chapter, that entitled "Locomotive Train Haulage," has been added, practically every chapter in the book has been completely revised and further illustrated. Tabulated data representing actual operating conditions in railway practice have been increased by 50 per cent., and more than 50 illustrations have been added.

General News Section

Annual Electrical Night Meeting of the New York Railroad Club

The New York Railroad Club will hold its annual electrical night at the Engineering Societies' building, 29 West 39th street, New York, on Friday, March 17, at which time George Gibbs, of Gibbs & Hill, consulting engineers, New York, will present a paper reviewing the Report on the Electrification of the Chicago Terminals. Several prominent railway electrical engineers and other engineers interested in the subject have been invited to participate in the discussion.

National Railway Appliance Show at Chicago

The National Railway Appliance Show, to be held March 20 to 26 at the Coliseum at Chicago, is one of the big things of the year with railroad men. This show has entirely outgrown its original scope of simply maintenance of way and track equipment so that it now contains a large number of exhibits which are of great interest to electrical men of the railroads.

Over 150 companies are represented at this show, but the following list includes only those companies which will exhibit material which should interest electrical men.

The Adams & Westlake Co., Chicago, Ill.
American Steel & Wire Co., Chicago, Ill.
Bryant Zinc Co., Chicago, Ill.
The Buda Co., Chicago, Ill.
Chicago Pneumatic Tool Co., Chicago, Ill.
Edison Storage Battery Co., Orange, N. J.
The Electric Storage Battery Co., Philadelphia, Pa.
Electric Railway Improvement Co., Cleveland, Ohio.
Fairbanks, Morse & Co., Chicago, Ill.
Federal Signal Co., Albany, N. Y.
The Fibre Conduit Co., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Hubbard & Co., Pittsburgh, Pa.
H. W. Johns-Manville Co., New York, N. Y.
Kalamazoo Railway Supply Co., Kalamazoo, Mich.
Kerite Insulated Wire & Cable Co., New York, N. Y.
National Carbon Co., Cleveland, Ohio.
Northwestern Motor Co., Eau Claire, Wis.
The Okonite Co., New York, N. Y.
Standard Underground Cable Co., Pittsburgh, Pa.
Western Electric Co., New York, N. Y.

A New Gibbs Train Connector

Improvements on the Standard Gibb train connector have just been placed on the market by the Central Electric Company, Chicago. These improvements were suggested by practical car lighting men, and consist of an automatic closing dust cover, which is a part of the connector yoke. The complete connector is shown in Fig. 1. When closed the dust cover will prevent the entrance of dust and dirt which accumulates on the contacts. The cover is hinged to the forward part of the yoke, and closes by means of a suitable spring and is effectually insulated. In this type of 3-G connector the yoke may be removed by loosening one hexagonal capscrew on the side of the connector, as shown in the illustration, and two wing nuts are used for tightening the plug, giving more uniform pressure and stability to the contact making parts of this connector. This connector is provided with an indicating automatic loop and also a wedge-clamp, by which the connector cable is permanently connected to the fingers of the connector without soldering. When ordering Gibbs train connectors with the improvements as above named, it is suggested that they be specified as follows: Give type number, and if the 3-G type is desired, signify 3-G with automatic loop, wedge-clamp, and dust cover. A dust cover, which is available for connectors already installed, is shown in Fig. 2. New catalogues showing these improved connectors and dust covers are now being prepared and will be sent on request.

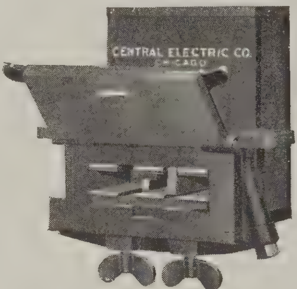
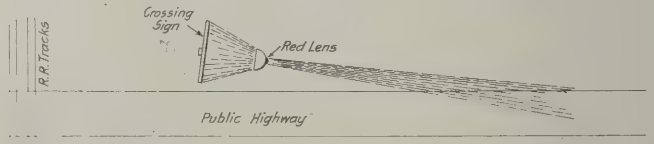


Fig. 1. Improved Gibbs 3-G Train Connector.

Fig. 2. Dust Cover for Application to 3-G Train Connectors Already Installed

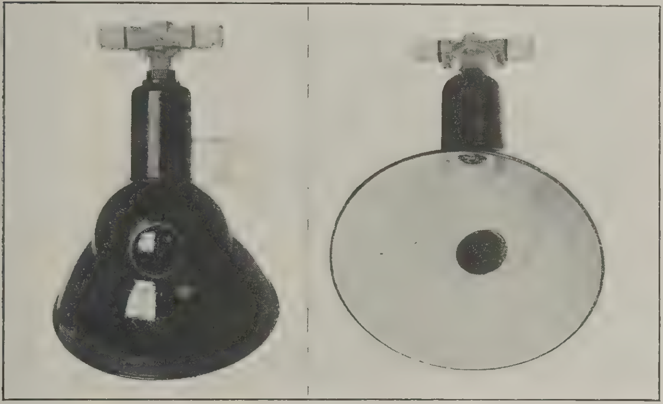
Combination Danger Signal and Sign Light

In order to meet the safety requirements at crossings which are more or less dangerous, a new type of reflector has recently been designed by the Benjamin Electric & Manufacturing Company, working in conjunction with the electrical department of one of the leading Eastern railroads. The purpose of this reflector is to illuminate the crossing danger sign at night, and at the same time to direct a strong beam of red light up the road approaching the railroad crossing so that motor cars will be warned of the crossing danger a quarter of a mile before actually reaching the crossing.



Sketch Showing a Typical Installation of the Combination Danger Signal and Sign Light

The reflector is simply a standard angle type unit which has a 3-in. fresnal lens set into the back. A copper ring is spun around the lens and this serves to hold it rigidly in place in the reflector. A removable Mogul socket is employed, as shown in Fig. 2, and this has an automatic short circuiting device for use with series circuits which short circuits the unit, re-establishing the circuit in case the lamp burns out when operated in series with arc or other series mazdas. When the socket is removed, a pair of clips, normally forced apart by the contact blades of the socket, are allowed to come together so that the series circuit can never be broken by removing the unit.



Two Views of the New Combination Danger Signal and Sign Lighting Fixture Showing the 3-in. Red Fresnal Lens

The Benjamin lamp grip feature which prevents the lamp from working loose is employed in this type of reflector as in all other standard railroad type units.

This combination danger signal and sign lighting lamp can of course be operated either from a series street lighting circuit or on a multiple circuit, and by a proper arrangement for control can be made to operate either all the time or only when trains are approaching, as desired.

No. 318 Simplex Pole Jack

Electrical, telegraph and signal departments of railroads frequently have occasion to move poles from one location to another—or to take them out entirely. The removal of the poles is by no means an easy job, as it requires considerable time in addition to a number of men.

No. 318 Simplex Pole Jack has been especially designed for the purpose of removing poles. It supersedes in effort, time and expense all former means of pulling a pole and eliminates the necessity of digging around the pole.

In the photograph shown the pole was about five feet in the ground, had a big butt, and had been embedded solid for years. It took just 19 minutes for the No. 318 to pull it straight from the earth—with no preliminary digging around the pole. The time necessary by former methods of digging first and operating with roller and rope would have approximated an hour and a half; hence as a labor saving device the tool should quickly pay for itself through the saving of time to the entire pole crew.

No. 318 is single acting, operating on the down stroke of the lever or tripping at any point. In this way, at the end of its entire lift, the cap may be dropped back to take a new hold on the pole. The capacity is 15 tons; lift 24 in. and height 39 in. It pivots on its own base from 30 to 90 degrees to the horizontal, and follows the angle of the pole being pulled.

The cap is recessed to firmly hold the links of a chain when they are dropped in position. The chain, with grabhook attached, furnished with the jack, is of sufficient length to wrap once around the average pole. An I-beam base support acts as a substantial foundation where the ground is soft or hollowed. The standard is a heavy malleable casting. All other parts are drop forgings. The double lever socket insures a convenient position for the lever bar with the jack at any angle. A 5-ft. steel lever bar of pinch bar design also forms part of the equipment.

The No. 318 Simplex Jack in Operation

This jack is manufactured by Templeton, Kenly & Co., Limited, Chicago.

Trade Publications

Deltabeston Wires is the title of a pamphlet issued by the B. & W. Fuse Company, Providence, R. I., with the object of acquainting the trade with the development which this company has recently made in the manufacture of fireproof wires. In this catalogue are listed and described asbestos-covered wires for practically every kind of work and condition of service. The manufacturers say that in the development of Deltabeston products they have departed from the conventional forms of asbestos insulation in which inflammable materials are combined with the asbestos, and have produced an insulation which is in fact, as well as in name, fireproof. The various types of wires are illustrated in color, and complete data about each wire is given. With the exception of the well-known Deltabeston magnet wire, the wires listed in this new pamphlet are all new, and for this reason the pamphlet should be in the hands of everyone interested in fireproof wires. A copy will be sent on request to the D. & W. Fuse Company.

The Edison Battery.—The Edison Storage Battery Company of Orange, N. J., has prepared for the National Educational Association Joint Committee of Physics an interesting and instructive monograph on the Edison storage battery. This monograph, which is in pamphlet form, has been prepared to facilitate the making of education in storage battery operation more practical, and for this reason it is written in simple language, easy to understand. The scope of this monograph covers the search for the ideal storage battery, the nickel-iron alkaline cell, a trip through the factory, normal characteristics of the Edison storage battery, emergency characteristics of the Edison storage battery, the chemistry of the Edison storage battery, its school laboratory uses, methods of charging Edison batteries for school use, battery tests and laboratory experiments, determining the characteristics of a battery cell, observation and conclusions, and general data and trade dimensions of Edison storage batteries. The pamphlet is fully illustrated with views of the battery parts, factory processes and characteristic curves. Copies of this monograph may be had upon application to J. A. Randall, chairman, Joint Committee of Physics, Pratt Institute, Brooklyn, N. Y.

Western Electric Company.—The sixth edition of "How to Figure Illumination and a Complete Catalogue of Sunbeam Mazda Lamps" has just been published by the Western Electric Company, Inc. This booklet gives tables and complete illuminating data, as well as picturing and describing the various sizes of Sunbeam Mazda lamps. By means of the information contained in this booklet, anyone can readily lay out lighting installations adapted to the requirements of any class of lighting. A copy of this booklet will be mailed to anyone upon request. Address the Western Electric Company, Inc., at Chicago, New York, or any branch house in the United States.

Switches, Motors and Switchboards.—The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has recently issued leaflets 3551-A, 3765, 3833, 3835, 3837 and 3849, describing the type F alternating current magnetic switches, railway motors from 90 k.w. to 34 k.w. capacity, and the type EA switchboard for alternating current of 240 and 480 volts. These leaflets thoroughly describe the apparatus and illustrate their construction in detail.

New Western Electric Year Book.—The second edition of the Western Electric Year Book is out. It is known as the "Electrical Supply Year Book for 1916," and is similar to its predecessor which, it will be remembered, caused such a favorable impression in the electrical supply business when it made its appearance last year. The current book continues the practice of a simple series of list prices upon which a basic discount applies, such as discount indicating to the holder of the catalog his approximate price for all the articles listed. This method of pricing, which was called revolutionary, was received so enthusiastically by the trade that the present year book is the result of an unanimous demand for its continuance.

New Westinghouse Electric & Mfg. Co. Leaflets.—Westinghouse Railway Motors, Nos. 306-V, 307-V, 333-V and 547-A are thoroughly described and illustrated in a series of leaflets, Nos. 3837, 3765, 3833 and 3835, respectively. The particular characteristics of these motors, together with detail views of construction and operating curves, are given.

Alternating Current Magnet Switches, Type F, for industrial service, are described in leaflet No. 3551-A. These switches have been designed with a view to fulfill the severest requirements of industrial service, and their details of construction and operating characteristics are given in the leaflet, together with illustrations of them mounted on panels.

Alternating Current Low-Voltage Switches, Type EA, are described and illustrated in leaflet 3849. Diagrams of typical connections are given and the construction of the board thoroughly described.

"Norma" Precision Bearings is the title of a complete and interesting catalog just published by the Norma Company of America; the plan for this catalog contemplates a two-fold function. For those wishing only to draw their own conclusions from plain statements of facts, uninfluenced by argument, the descriptive section, pages 4 to 18, presents the bare essentials of Norma types. For those wishing to pursue the subject further, to learn the why and wherefore of specific points of designs, pages 19 to 38 offer a brief analysis of the principles of anti-friction efficiency in particular relation to Norma bearings. The pages from 39 to 99 contain tabular data of equal value to both classes of readers. The application drawings, pages 102 to 115, are full of suggestions for the draftsman and designing engineer. And the closing section, pages 116 to 120, on the selection of bearings offers suggestions which should go far toward safeguarding against bearing troubles.

Copies of this catalog will be furnished by the Norma Company of America, 1790 Broadway, New York, on request.

Leakage of Current from Electric Railways

A study of the problems connected with the leakage of current from electric railways has recently been completed by the Bureau of Standards, Department of Commerce, and the results just published in Technologic Paper No. 63.

The theory of the leakage of current from electric railway tracks is developed mathematically, and curves are then plotted to aid in the interpretation of the results. The conclusions to be drawn from the formulas and curves are discussed with special reference to practical problems in electrolysis. It is shown how the escape of electricity from the rails is affected by increasing the track conductivity, as by careful bonding of all joints; by the use of a high resistance roadbed; and by shortening the distance over which a power house or substation furnishes power.

The paper is intended primarily for electric railway engineers and others familiar with electrolysis problems. Copies may be obtained free of charge by persons interested upon application to the Bureau of Standards, Washington, D. C.

How to Figure Illumination

A new edition, the sixth, of the complete little handbook, "How to Figure Illumination," is ready for distribution.

This booklet lists complete tables and full illuminating data as well as illustrating and describing with complete characteristics all the various sizes and styles of Sunbeam Mazda lamps. The information contained in this booklet, together with curves and illustrative matter is sufficiently complete to enable one to lay out any illumination plan. A copy of this booklet will be mailed, gratis, to anybody writing for it to the Western Electric Company at Chicago, New York or any of their distributing houses.

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The Lumen Basis for Rating Incandescent Lamps

On page 283 of the March *Railway Electrical Engineer* appears a discussion on the desirability of adopting the lumen as the unit on which to base the rating of incandescent lamps. The whole question of rating lamps has been in more or less of a turmoil since the introduction of the tungsten filament, due largely to the changes in lamp rating and to the steady improvement of lamp design and efficiency, and it is now evident that the introduction and development of Type "C" Mazdas is going to force still another change in the basis for rating illuminants. At present the efficiency of a lamp is stated as watts per mean horizontal candle power, but, due to the disposition of the filament in the Type "C" lamp, which produces a greater candle power in a downward direction than was produced in the older type tungsten lamp, a rating based on mean horizontal candle power does not give a fair indication of the light-giving properties of the Type "C" lamp in comparison with the vacuum type. For this reason some basis which will take into account the average candle power emanating in all directions or, in other words, the total light flux must be adopted.

A rating based on either the mean spherical candle power or the lumen would fill these requirements, but it now becomes necessary to determine which of these units is the most desirable. It has been stated by one prominent railway electrical engineer that there are numerous reasons why the lumen basis should be adopted, but none whatever as to why the mean spherical candle power basis should be adopted. In any event, this is a problem in which every railway electrical engineer should be vitally interested. There is undoubtedly going to be some change made in the rating of incandescent lamps in the near future and the representatives of the users of one-tenth of all the incandescent lamps consumed in the United States will evidently, if well organized and unanimous in their convictions, influence the choice of the proper and logical unit.

On page 312 of this issue we are publishing under "Letters to the Editor" three letters which have come to us from men who are well known in their profession, and the arguments presented therein in favor of the lumen are most interesting and instructive. It is hoped that others, who are interested in this subject, will send us their views on the proper basis for rating lamps, for publication in these columns, so that the sentiment in favor of either one of these units will be crystallized before the October convention at which time decisive action can be taken.

Anti-Friction Bearings for Shop Motors

One of the biggest questions which will be up before the coming A. R. E. E. convention will be the proposition to recommend to the railroads that they specify either roller or ball bearings for all shop motors, and it is hoped that the association will go on record as favoring such a specification. Considering the absolute reliability of anti-friction bearings as manufactured today, there is evidently no good reason why they should not be applied to shop motors in railroad service. The argument in favor of using anti-friction bearings on such motors is not mere economy from the power consumption standpoint, as recent tests show that except under conditions of frequent starting, the power taken by a motor equipped with roller or ball bearings is not appreciably less than the power taken by a motor equipped with sleeve bearings. The arguments in favor of anti-friction bearings are rather along the lines of increased reliability and reduced maintenance cost. Experience with anti-friction bearings in axle generators has demonstrated that such bearings do not require an inspection oftener than once every six months in contrast to fortnightly or monthly inspection required by sleeve bearings. It is true that motors equipped with sleeve bearings have run continuously and successfully for six months without inspection, but such cases are exceptions and the practice of allowing such motors to run for that period without inspection should not be countenanced.

The fact that anti-friction bearings would eliminate the use of oil in motors is another important point. Oil, such as is required in sleeve bearings, is frequently drawn into the armature and field windings where it acts as the most efficient dust collector. With anti-friction bearings, where simply grease is used, the armature and fields remain perfectly dry and thus can easily be blown off so as to prevent the collection of a conducting layer of dust, which is liable to cause flash-overs and grounds and serious commutator troubles. Another important argument in favor of using anti-friction bearings is that motors so equipped can be shipped fully lubricated with no danger of slopping oil, and in this way all danger of starting the motor with no lubrication in the bearings is eliminated.

The use of ball or roller bearings also permit of more compact motor construction as such bearings are considerably shorter than sleeve bearings. In such cases the motor would not only be narrower and would, therefore, occupy less floor space but the distance between bearings would be less, thus resulting in more rigid construction throughout.

Another point we cannot overlook in favor of using anti-friction bearings on induction motors is that due to the reduction in the air gap that would be permitted its efficiency would be increased and power factor materially improved.

If the association desires to recommend the application of anti-friction bearings to shop motors in railway service, the next step would be to co-operate with the manufacturers of anti-friction bearings and of motors so as to decide on standard bearings and standard shafts for each size and type of motor. The interchangeability of bearings and shafts for all makes of motors would do a great deal towards simplifying the maintenance problem in all railroad shops.

Letters to the Editor

The Lumen Basis for Rating Incandescent Lamps

Altoona, Pa.

To the Editor of the Railway Electrical Engineer:

Referring to the editorial on page 283 of the March issue of the *Railway Electrical Engineer* on the subject of the method of rating incandescent lamps:

The basis used heretofore has been mean horizontal candlepower and watts. For lamps having approximately the same distribution curve, such as the carbon, metallized, tantalum and tungsten filament lamps operated in a vacuum, comparative readings were obtainable and the above basis was therefore satisfactory and the mean horizontal candlepower could properly be used to determine the efficiency of the lamp.

The development of the type "C" tungsten lamp, or lamp with a tungsten filament operating in a bulb filled with an inert gas, has changed the situation. Experience has shown that to obtain the best results with the type "C" lamp a radical change in the disposition of the filament must be made. This change gives an entirely different distribution curve, making the mean horizontal candlepower no longer of value as a comparison, and in order to obtain a comparison of the type "C" lamp with the older types it is necessary to evaluate them on the basis of total light emitted, i.e., lumens or a derivation of lumens, mean spherical candlepower.

The lumen is defined as the amount of light that will give one candlepower at any point on the interior of a sphere of one foot radius.

Mean spherical candlepower is the average of the candlepower emitted, measurements being made in all directions.

Therefore, it will be seen that the ratio between mean spherical candlepower and lumen is the ratio of the radius of a sphere to the area of the same sphere, or 1 to 4π or 1 to 12.5664+.

It is evident that a change in the method of rating illuminants must be made. The question is, shall the new standard be lumens or mean spherical candlepower? In either event the public will have to learn the value of the new standard, and it would appear that the idea of a lumen could be absorbed as readily as could mean spherical candlepower.

The present 25-watt lamp, SS-19 bulb, has an efficiency of 1.05 watts per candle (based on mean horizontal candlepower), or 20.95 candlepower, with a ratio of mean horizontal candlepower to mean spherical candlepower of 100 to 78. Therefore, the same lamp would be rated as 16.34 mean spherical candlepower with an efficiency of 1.54 watts per candle, while on the lumen basis it would be rated as having 205.35 lumens, or 8.21 lumens per watt.

It will be noted from the above that with the mean spherical candlepower rating the efficiency of the lamp in candles per watt is not given, but, instead, is stated as the reciprocal, i.e., watts per candle.

With the lumen basis the efficiency is given direct as lumens per watt, and as the efficiency of the lamp is improved the value of the term "lumens per watt" will be increased. On the other hand, with the mean spherical candlepower basis, the converse "watts per candle" would be decreasing.

As the "man on the street" does not, and for a long time would not, appreciate the difference between mean horizontal candlepower and mean spherical candlepower, it might, from the jobber's standpoint, be embarrassing to have to offer a 16+ candle-power lamp (m.s.c.p.) when the customer has heretofore been getting a 21-candlepower lamp (m.h.c.p.), and it might be difficult to explain the matter satisfactorily.

It is believed that with the lumen basis this difficulty would not appear as the term lumen is entirely new, and it would seem easier to learn the meaning of a new term than to revise one's idea as to the meaning of a term which is already familiar.

Therefore, to me, the lumen basis appears preferable to the mean spherical candlepower basis for rating incandescent lamps and other illuminants.

J. R. Sloan.

Baltimore, Md.

To the Editor of The Railway Electrical Engineer:

I have read with interest the editorial in the March issue of the *Railway Electrical Engineer* with reference to lumen basis for the rating of incandescent lamps.

I feel that this is a subject that should be given careful consideration by the Association of Railway Electrical Engineers as well as by electrical and car lighting representatives of the various railroads. Considering the widespread use of incandescent lamps, it might be inadvisable at this time to adopt a rating for all classes of lamps based on a unit that is so little known by others than illuminating and electrical engineers.

I am, however, in accord with the idea that the lumen is the correct and logical unit on which to base the rating of incandescent lamps and that it will ultimately be adopted. As far as those classes of incandescent lamps used almost exclusively by steam railroads are concerned, such as train lighting lamps and locomotive headlight lamps, I am in favor of adopting the lumen basis of rating at this time instead of the mean spherical candle power basis, which I now understand is being considered for train lighting lamps. The unit of mean spherical candle power is as little known by the laymen as the lumen and, due to its similarity with the term "mean horizontal candle power," with which the majority of the people are familiar, it will undoubtedly give rise to confusion. I believe the rating of these lamps in mean spherical candle power will be but a temporary expedient until the use of lumen becomes more general. When the rating of incandescent lamps was changed from horizontal candle power basis to the wattage basis considerable effort was required on part of the railroads to educate those using lamps in the use of the new term. In going to the mean spherical candle power basis this will have to be gone through again, and if a change to the lumen rating is made a little later on it will not only impose a considerable amount of additional work on the part of the users of lamps, but such relatively frequent changes will become confusing. If any changes, therefore, are to be made at the present time in the method of rating lamps used by steam railroads I am in favor of adopting the lumen basis. J. H. Davis.

New York, N. Y.

To the Editor of the Railway Electrical Engineer:

The editorial in your issue of March on the subject of rating of incandescent lamps presents a very clear and interesting statement of this question. The old-time rating of incandescent lamps in horizontal candle power was a relic of gas practice, because the candlepower of gas is measured in a horizontal direction. It is a practice which the electrical industry has outworn and which it is on the way to abolish. The logic of expressing the total luminous output of an incandescent lamp by giving its horizontal candle power only is about on a par with that of expressing the contents of a measure by giving its diameter only. As long as lamps had the same relative distribution of light, the mean horizontal candle power served the practical purposes of measuring indirectly their luminous output. With the introduction of gas filled lamps, where the distribution of light in different types varies greatly, this method of measuring fails completely. It is the introduction of the gas filled lamp, therefore, which is forcing a change from older methods of rating, and this not only for the reason given above, but also because the gas filled lamp does not lend itself readily to measurement in accordance with the methods hitherto employed with vacuum lamps.

The mean horizontal candle power of vacuum lamps is ordinarily determined by placing the lamp in a rotator in an upright position, rotating it at a suitable speed and measuring on a bar photometer the candle power given. This procedure is not applicable to the gas filled lamp because, for the most part, gas filled lamps require to be burned tip downward and hence cannot be used in the ordinary rotators. Their candle power is different tip upward from tip downward. Moreover, the candle power of a gas filled lamp varies as a result of rotation, and in general tends to increase with increased speeds of rotation. The difficulties of measuring the mean horizontal candle power of gas filled lamps, and the variable ratio between the mean horizontal candle power and the total luminous output lead directly to the adoption of other methods of measurement. Fortunately we have in the integrating sphere a very simple and satisfactory means of determining the total luminous output of lamps which is applicable as well to the vacuum as to the gas filled lamps. With modern photometric appliances, including the use of an integrating sphere, incandescent lamps of all classes can be measured more accurately and more rapidly than has hitherto been possible with the use of the bar photometer. As between the rating in mean spherical candles and in total lumens the measuring apparatus does not distinguish, it being only a question of the scale calibration whether one or the other units is read. However, for many practical reasons, most of which are mentioned in your editorial, the use of the lumen is preferable to that of the mean spherical candle.

Illuminating engineers are particularly interested in the introduction of the lumen rating for the reason that given the output in lumens of the illuminants to be used, the predetermination by computation of illumination values is very much simplified. The mean spherical candlepower is of no use in this connection until the lumens have been computed from it. Illumination computations on a candlepower basis involve operations from a vertical distribution curve giving candlepower at various angles. Given such curves, the point-by-point method of illumination computation may be used. This, while exact, is very laborious. It is usually sufficiently accurate and very much simpler to work from average values of illumination determinations as you have indicated in your editorial, first from the product of square feet of floor area times foot-candles required, which gives the total lumens which must be delivered on this area, and, second, from the total lumens of the lamps plus a value determined by previous experience of the proportion of the total luminous output of the lamps delivered on the floor area in question. The rough and ready determination of the number and size of the illuminants to produce a requisite illumination on a given area or in a given room becomes, if the lamps are rated in lumens, almost a matter of mental arithmetic. With a greater refinement of data the computation becomes no longer rough and ready, but sufficiently accurate for all practical purposes.

In view of the fact that as far as we can see today, the ultimate goal in the rating of illuminants is the rating in total lumens, and further that the change to mean spherical candlepower as an intermediate step would have considerable disadvantages, it would seem that the railway electrical engineers would make no mistake if they went at once to the lumen basis of rating.

Clayton H. Sharp, Technical Director,
Electrical Testing Laboratories.

Rotary Converters

Operation and Maintenance

By W. A. Campbell*

Rotary converters, as now manufactured, are, in the majority of cases, designed for self-starting, that is, they are started from the alternating current supply without introducing a starting motor. We will, therefore, confine our discussion to this type. When an alternating current is switched to the armature of a rotary converter it induces a magnetic field in the pole pieces, but, due to the magnetic hysteresis in these pole pieces, the field lags behind the armature current. In this way a torque is produced, causing the armature to rotate and gradually come up to synchronous speed. If full line voltage was applied to the converter when starting, an excessive and destructive magnetizing current would be taken. To reduce this current at starting, transformers are supplied with low voltage taps on the secondary windings, as shown in Figs. 1 and 2.

The connections for a three-phase rotary are shown in Fig. 1, and for a six-phase machine in Fig. 2. The rotary differs from a direct current generator in that the voltage cannot be regulated by the field rheostat. The voltage can be regulated by varying the field current, however, if a reactance is inserted in series with the low-tension alternating current leads to the rotary, as shown in Fig. 1. Another way, and probably the most common way, of obtaining the required regulation is to use an induction regulator connected in series with the low-tension leads, as shown in Fig. 2. The required regulation of the direct current voltage is then obtained by varying the alternating current voltage with the regulator.

When starting from the alternating current side, the armature bears the same relation to the shunt field coils as the low-tension coil of a stationary transformer does to the high-tension coil, the number of turns in the shunt coils being large compared with the armature turns. It is possible, therefore, when starting to induce an excessive voltage in the field coils, which would rupture the insulation of the coils if special precautions were not taken. To prevent the induction of this excessive voltage, a field break up and reversing switch is provided, which breaks up the field circuit between the shunt coils, as shown in Fig. 3. The reason that this method of starting is more popular than any other is because of its simplicity. No extra apparatus is required, and the difficulties of synchronizing are eliminated. This is of special importance in railway work where the load fluctuates rapidly.

Starting

After seeing that all the switches are open, the oil-switch and then the first starting switch are closed. The machine will then come up to speed and lock in step. When this takes place the voltmeter needle will cease to oscillate and will come to rest, on the scale, indicating positive polarity, or off the scale, indicating negative polarity. If the polarity is negative it will be necessary to reverse the polarity of the machine. This is done by the field break up and reversing switch shown in Fig. 3. This switch should be closed in the position which will reverse the connections to the field coils, thus reversing the direction of the current in the coils. The reversed current will now set up a flux which will oppose and overcome the flux induced by the armature current, and will thus cause the armature to drop in speed until it slips a pole. When the potential across the brushes is reduced to zero there is no field current and the polarity will be reversed by the armature again, inducing a flux in the pole pieces, but with the proper polarity. The field break up switch is now opened and the armature will speed up to synchronous speed. The switch is then closed in the operating position. When the polarity is positive the switch is closed in the operating position as it is then unnecessary to reverse the field. The starting switch is now thrown to the running position and the machine is ready to parallel in on the direct current side.

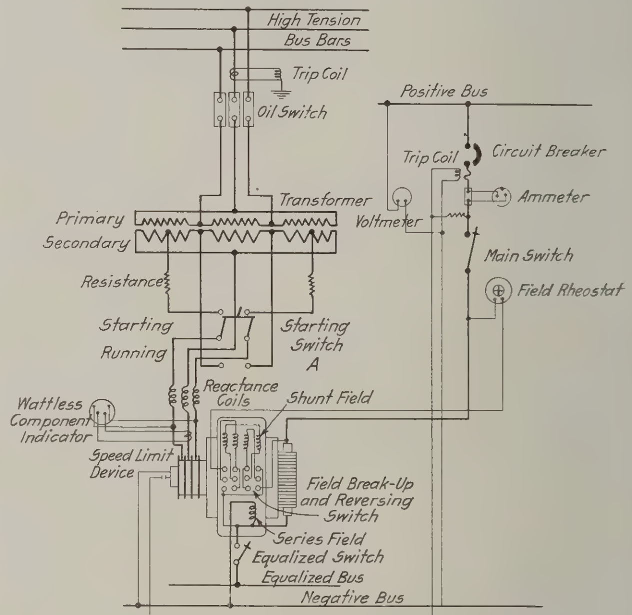

Fig. 1—Connection Diagram for a Three-Phase Rotary Convertor Railway Substation

The above gives a general idea of the switching operations, but we will give them again in brief as a matter of routine.

Switching Operations:—Starting

1. See that all switches are open, including field switch and plug machine to the voltmeter.
2. Close oil switch.
3. Close starting switches upward "A" for three phase and "AA" for six phase, Figs. 1 and 2.
4. When machine comes up to speed see that polarity is correct. Reversing if necessary.
5. Close equalizer switch (not required if there is only one machine).

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*Operator, Duluth Street Railway Co., Duluth, Minn.

6. Close field break up and reversing switch.
7. Throw switch "A" from top to bottom contacts for both three phase and six phase machine.
7a. Throw switch "A" of the six phase machine from top to bottom contacts.
8. See that oil rings in bearings are revolving.
9. Adjust voltage to bus bar voltage and power factor so that for a railway machine it is taking 25 per cent lagging current with no load.
10. Close direct current circuit-breaker.
11. Close main switch.

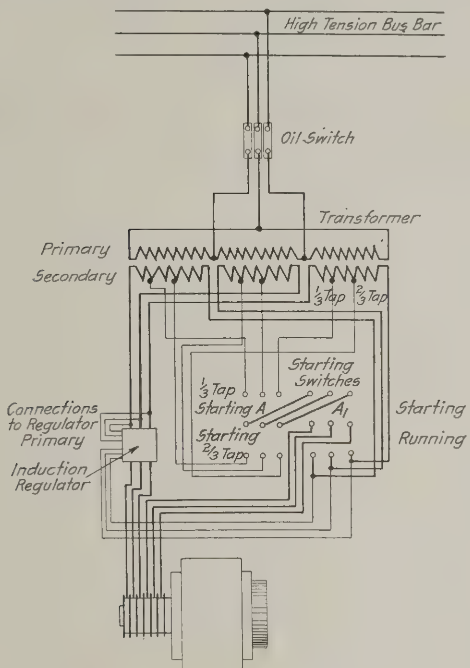


Fig. 2—Connection Diagram for a Six-Phase Rotary Convertor Railway Substation. The Direct Current Connections, Which Are Not Shown, Would Be the Same as Shown for the Three-Phase Rotary in Fig 1.

Shutting Down

1. Open direct current circuit-breaker.
2. Open main switch.
3. Trip oil switch.
4. Allow machine to reduce its speed until the voltage is 100 or less.
5. Open field switch.
6. Open equalizer switch.
7. When voltage falls to zero open starting switch.

Don'ts

It would be well at this time to call attention to a few things that should not be done.

1. Don't close a switch slowly.
2. Don't close a circuit-breaker with main switch closed.
3. Don't start machine with field switch closed in either position.
4. Don't try to parallel machines without having first closed equalizer switch.
5. Don't open field switch before the voltage drops to 100 volts or less. The arc formed may do damage to the switch.
6. Don't open oil switch if machine is on starting tap and the field switch is closed.
7. Don't open the starting switch before the voltage reaches zero.
8. Don't run machine on low, leading or lagging power factor. This will unduly heat up the armature of the machine.
9. Don't try to raise the voltage of the rotary by means of the field rheostat; this will only vary the power factor. Transformers are usually provided with percentage voltage taps on the primary coils, and if no other means is provided for raising the voltage of the converter the connections of the high tension leads to these taps should be changed to give a higher secondary voltage, thus raising the direct current voltage of the machine.

Operation

Cleanliness is one of the most important factors in the successful operation of rotary converters. It is more difficult to maintain this type of machine than many others because of its concentrated windings which collect dirt and dust easily. When a supply of compressed air is available it should be used to blow the dust out of the armature and collector rings. If compressed air is not available the spaces between the collector rings should be carefully wiped out, thus preventing short circuits by copper dust lodging between the rings. End play devices are used on this class of machine to move the armature to and fro, in a horizontal direction. These devices should be adjusted to give the maximum amount of travel without allowing the armature to pound on the bearings. If this end play is carefully attended to and kept as it should be there should be no trouble with grooves forming on the commutator.

Sanding the Commutator

It may be necessary to sand the commutator if it becomes rough, especially after a bad flash-over. For this purpose, a block of wood, rounded to approximately the same radius as that of the commutator, should be used. To give a certain amount of flexibility to the block about twelve sheets of sand paper should be screwed to it. If the commutator is rough, No. 1 sand paper followed by No. 00 ought to be used, if not very rough the No. 00 is sufficient for the purpose. For finishing, a sheet of No. 00 sand paper backed with felt will give very good results, especially if oil is used on the sand paper. The oil will cause the copper dust to adhere to the paper and in this way prevent it from being embedded in the mica.

Brushes also require considerable care. They should be examined from time to time to see that their contact surface is in good condition, and if they are not so found they should be sand papered. This is done by setting the required tension on the brush with the tension springs on the brushholder. A strip of sand paper is then inserted under the brush and pulled in the direction of rotation of the armature; the brush is then raised and the paper slipped back and the brush lowered on the paper again. This process is continued until the required contact surface is obtained. For this purpose No. 1½ sand paper is used with No. 00 for finishing.

Care should be taken to prevent sparking at the brushes, and, if necessary, the brushes should be moved to prevent this. It is sometimes found that a machine will spark badly when starting with the brushes in the operating position. When this occurs the brushes should be rocked back to the exact neutral while starting and then rocked forward to the operating position before the load is put on the machine. When operating this way it is advisable to put two marks on the brush gear, one showing the position of the brushes for starting, the other the operating position. The brushes on the slip rings also require attention as it sometimes happens that the slip ring does not travel completely across the face of the brush. This will cause a ridge or fin to form on the edge of the brush, which should be removed. Copper dust collecting in the brush holders, thereby causing the brushes to stick, is another fruitful source of trouble.

Bearings should also receive attention to insure that they do not get unduly hot, and care should be taken to keep the oil at the proper level. The oil should be changed from time to time, about once every three or four months, if a high-grade oil is used.

Attention must also be given the switches and switch gear so as to keep them in proper working order. Knife switches ought to have their jaws cleaned out to remove the dust that collects in them and the contacts of the switch blade must be kept clean. This is necessary to prevent cutting between the contact surfaces and also to prevent overheating.

The speed limit device requires attention and cleaning to insure its proper operation. It is a good practice to test it out from time to time. This may be done by running the machine from the direct current side, decreasing the field strength until a speed is attained which will operate the device. The speed can be checked by a tachometer.

Before leaving this part of the discussion it may be again pointed out that one of the main requisites for successful operation is cleanliness.

We will now take up the most common troubles met with in operating rotary converters, which are:

1. Overheating.
2. Sparking at the commutator.
3. Difficulty in obtaining regulation.
4. Difficulty in starting.
5. Difficulty in parallel operation.
6. Grounds.

Overheating

Overload.—The converter may be overloaded on the direct current side. This can be ascertained from an observation of the direct current ammeter and voltmeter. If possible the load should be reduced.

Railway machines are compound wound and it may be that when two or more machines are running in parallel they do not share the load properly. In such cases one of the machines may "hog" the load and become overloaded. To remedy this the series field of the overloaded machine should be adjusted to give the required compounding. One of the other machines is first put on load separately, its shunt field being adjusted to give 25 per cent. lagging current at no load. When the load increases the added excitation due to its series field brings the power factor up to unity, and the particular load at which this occurs should be noted. From this data it is possible to adjust the series field on the defective machine. To do this its shunt field is also set to give 25 per cent. lagging current and a portion of the current is shunted past the series field with a shunt until the machine gives unity power factor at the same load that the first machine did. When these tests are being made it is absolutely necessary that the brushes be set in their operating position.

Operating With Low-power Factor.—It must be remembered that when operating at a low-power factor there will be a large wattless current circulating in the armature winding. This wattless current, together with the energy current, will heat the windings. Therefore, if a machine is operating at full load but at a low-power factor the heating will be much in excess of normal. The remedy for this condition is evidently to adjust the field to give unity power factor at full load.

Sparking

Sparking at the Brushes.—This will heat up the commutator. The brushes should be moved to a point at which the sparking ceases. Sparking will also be caused by the field becoming distorted, and the reason for this distortion may be due to incorrect brush setting or to operating at a low-power factor.

Internal Short Circuit in Armature Winding.—This will manifest itself by scorching the coil and by smoking. If the coil is damaged inside of the slot it will be found that the best practice is to replace the damaged coil by a new one rather than to repair the old coil, but if the coil is damaged outside of the slot it should be repaired.

Field Coil Short-Circuited.—A short-circuit in the field coil will cause an unbalancing of the armature current, and a circulating current will result which will cause the equalizer rings to become hotter than normal. It is also true that the short-circuited coil will be cooler than the others, and they in turn will be hotter than they are normally. Measurement of voltage drops should also be taken across each field coil. The one giving the smallest drop will be the short-circuited coil.

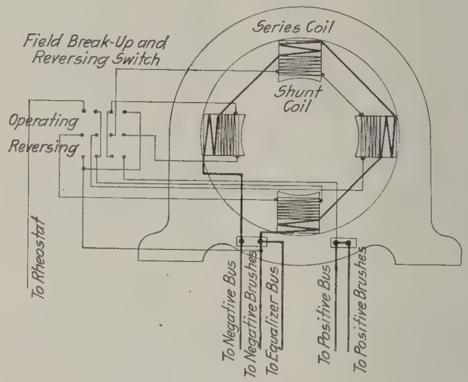


Fig. 3—Diagram of Field Connections for a Rotary Convertor

Open Circuit in Armature.—This trouble will show up in the same manner as in a direct current generator, by a ring of fire around the commutator. The machine should be shut down and an examination made of the windings. Most rotaries are now supplied with bar-wound armatures so that the open circuit will generally be at the soldered connections at the end windings and at the commutator.

High Bars in Commutators.—This will cause chattering and sparking of the brakes. The remedy is to shut down the machine and tighten up the commutator bolts. Then grind the commutator to remove the high part of the bar or bars.

Ridges on Commutator.—This is due to an incorrect adjustment of the end play device, which should be adjusted to give full travel to the armature. The brushes should also be staggered, which should be done so that all the brushes on studs of like polarity are staggered with reference to each other. The commutator should be sanded to remove the ridges. When sanding commutators the direct current side should not be loaded.

Incorrect Spacing of Brushes.—The brush studs should be moved to give the correct spacing. This spacing should be checked by wrapping a strip of paper around the commutator so that the ends meet exactly. This strip is then divided up into as many equal spaces as there are brush studs, using great care to get the dimensions exactly alike. This strip is again wrapped around the commutator and the brushes then set at the marks on the paper.

Reversed Armature Coil.—It is unlikely that this would happen with a bar-wound armature, it being practically impossible to connect the bars incorrectly.

Reversed Field Coil.—This will cause excessive sparking at the brushes. To determine if a coil is reversed, excite the coils from a direct current source and test out with a bar of iron placed between adjacent pole tips. If the poles are of the correct polarity the iron will be strongly attracted, otherwise there will be very little attraction.

Regulation

Difficulty in Obtaining Regulation.—Failure to obtain regulation with external reactance will be caused by a broken field connection. Examine all connections carefully for the break. In case it cannot be seen after such an examination it can be found in the following manner. With the machine running, connect a voltmeter to the negative brush. Then with the other lead explore around the field. A series of deflections will be obtained until the break is reached. When it is passed there will be no deflection on the voltmeter. The break will then be between the point at which the last deflection was obtained and the first point at which the voltmeter did not give a reading. The same results can be obtained by ringing out the field with a magneto, proceeding in a manner similar to the voltmeter method. In this case, however, the machine will be shut down while the test is being made.

Failure to Obtain Regulation With Induction Regulators.—In this case the trouble is not in the machine but in the regulator. It may be caused by a short-circuit over part of the series winding or by an open circuit in the primary or exciting winding. This will cause a large voltage drop across the regulator, thus decreasing the direct current voltage.

Starting

Difficulty in Starting.—This may be caused by a broken connection or a lead being accidentally disconnected when the machine is standing. Examine all connections and transformer taps until break is located.

Heavy Current Taken at the Starting by Six-Phase Machine.—This will probably be due to one phase being reversed. Insert ammeters in the leads to the rotary and observe the current taken when starting. The phase taking the greatest current will be the one that is reversed. Shut down the machine and reverse the connections in that phase.

Direction of Rotation Reversed.—This is corrected by interchanging any two phases. In the six-phase machine both wires of both phases must be interchanged.

Parallel Operation.—The polarity of the machine may be reversed when starting, and this should be connected as already explained.

Series Field Bucking Shunt Field.—If a machine is operating alone, with its series field bucking the shunt field it will manifest this fact, when, with increase of load, the direct current voltage falls off and the power factor decreases.

Paralleling

Operating in Parallel.—When the negative and equalizer switches are closed the series field will be excited by the machine already running. If when these switches are closed the direct current voltage falls off it shows that the series field is bucking the shunt field. The machine should be shut down and the series field connections reversed.

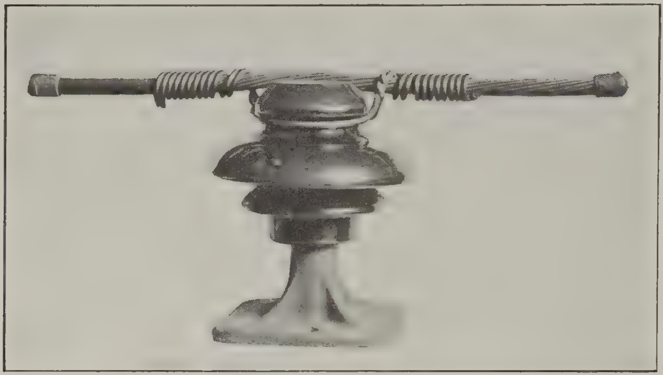
The Recent Electrical Tie-Up on the Long Island

On Wednesday, March 15, the electrified lines of the Long Island suffered a complete tie-up, due to the effect of a severe wind and snowstorm on their electric transmission lines. The railroad operates 800 trains a day, and about 200 of them were unable to move after the power was lost early Wednesday morning. These trains were stalled at various points on the system until steam locomotives could be despatched to their assistance. The trouble started at 7:50 in the morning and by 10:30 the power on all lines was completely shut off, except between the Pennsylvania Station and Jamaica, where some power was available up until 2 o'clock in the afternoon. The electric service was reinstated about 4.30 p.m.

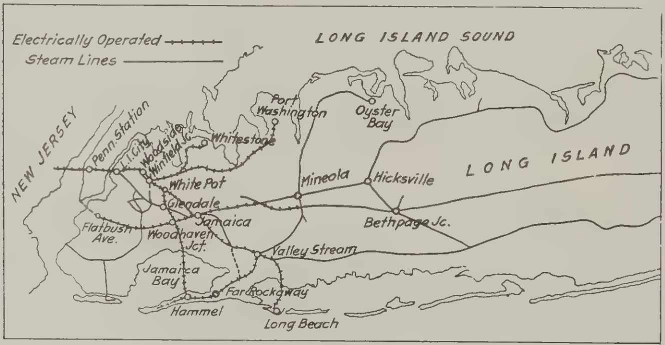
One of the stalled trains happened to be on the Jamaica Bay trestle when the third-rail went dead, and three others were stalled on the Flushing meadows midway between Corona and Flushing on the Northside division for nearly two hours. The train on the Jamaica Bay trestle was finally hauled to the nearest station by a steam locomotive.

Although other storms have visited Long Island, which in many cases were more severe than the one on Wednesday, notably the recent storm of December 13, 1915, which caused so much trouble on the New York, New Haven & Hartford, this is the first trouble of its kind that has been experienced since the Long Island lines were electrified in 1905. In many respects the trouble on the transmission lines was peculiar in its character. From the result of the high winds and the weight of the half-inch covering of ice the wires whipped up and down in a vertical direction with such force that insulators and tie wires were broken. The peculiar thing about the trouble is that all of the wires were not affected in a similar manner. While those in one span would whip up and down, and around in circles, as though they had convulsions, other wires in the same span or in adjacent spans would be almost quiet. At the present time this trouble can only be ascribed to some unusual condition. It was possibly caused by a certain combination of the unequal weights of sleet on the wires in combination with the gusty wind. The whole effect seemed to be one which would result from periodic and forcible lengthening and shortening of the spans.

The unusual stresses set up in the line by this whipping action sheered the tops entirely off of a number of insulators, broke many others, and in some instances caused the cables to tear away from the tie wires which fastened them to the insulators. As the main wires became detached from the insulators, either through the failure of the insulator itself or because of the failure of the tie wire, they dropped to the cross-arms. In many instances the wires of the different phases, dropping in this way, came together some place in the span, due to the reduced spacing, and thus became short-circuited. Where the cross-arms were of steel the wires were, of course, grounded when they fell from the insulators. This condition of affairs was prevalent on all feeders scattered over the entire system west of Mineola, particularly on the main transmission line between Harold avenue and Whitepot. The direction of the winds was a little east of north, and it is interesting to note that the direction of the transmission lines most affected was approximately at right angles to the wind or, in other words, they ran from northwest to southeast. The east and west lines were not affected.



One of the High Tension Insulators Showing How the 250,000 C. M. Cable Is Attached to It By the Tie Wire



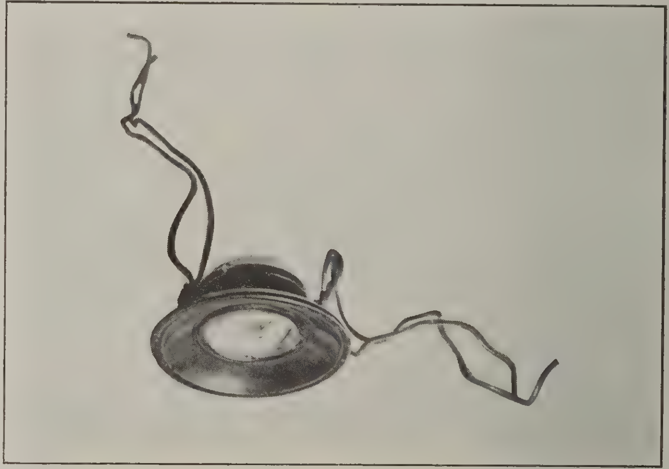
Map of the Long Island Lines

The cables used in the transmission lines were, in all cases, of 250,000 circular mills cross section, and the average span was 150 feet. From Long Island city to Winfield there are eight 3-phase circuits on each steel tower, from there on each tower carries only six 3-phase circuits. In no case did the ice on these wires reach more than one-half inch in thickness.

At 7:50 a.m. the feeders began tripping out one after another with increasing frequency until finally all trunk line feeders were out of service with the exception of the ones feeding Winfield from the Long Island city power house. It was attempted from time to time by cutting out single phases of different feeders to make up one good feeder between the power house and Woodhaven junction. In this way the sub-stations on Atlantic avenue were kept running intermittingly for two or three hours. The operation of the Winfield sub-station also enabled fair service to be maintained between Jamaica and the Pennsylvania station until 2 o'clock in the afternoon. Some trains on the Port Washington branch were also able to move along at a low rate of speed by the current furnished from the Winfield sub-station.

The first trouble was noticed at Woodside junction, which is a short distance southeast of Long Island city, and a little later trouble was reported at Whitepot, about two miles further down the main line in the same direction. Linemen were immediately sent to these places to make necessary repairs, but by the time they arrived on the scene the trouble had reached such proportions that they could not handle it; it was, however, fortunate that they were at that part of the line when all of the service was finally cut off, as it was then difficult to transport men anywhere until steam engines could be procured.

When it became evident that so many wires were in trouble that it was impossible to keep a feeder working between the power house at Long Island city and Woodhaven junction, the feeders were killed and all the linemen who could be secured were sent out to repair the trouble as quickly as possible. These men travelled on steam trains, and, in many cases, hired automobiles were used to reach the points where the wires were known to be in bad condition. Light gasoline and electric emergency cars, which under normal conditions transport the emergency crews, could not be used at this time because of the sleet and ice on the rails.



One of the Same Insulators Which Failed During the Storm

At about 2 o'clock it finally became necessary to cut out the one good feeder remaining between the power house and Winfield, and from then on until 4:30 there was no power whatever on the system.

The general plan used in making the repairs to the damaged transmission lines was to drop men and material along the line, wherever serious trouble was found, from a steam work train. This train shuttled back and forth, transferring the men from one place to another and keeping them supplied with material. By 4:30 in the afternoon the transmission line between Long Island city and Winfield was cleaned up, which allowed electric service to start between Jamaica and Port Washington and Jamaica and Whitestone Landing. By 5:45 p.m. the transmission line between Winfield and Woodhaven junction was ready for service, which allowed electric operation west to Flatbush terminal in Brooklyn, which part of the line was fed from underground feeders, and east to Hempstead, where the transmission lines run east and west and were, therefore, not affected. The repair gangs worked until midnight on the transmission line from Rockaway Junction to Valley Stream, and from there to Hammel, which, when finally placed in service, allowed electric trains to operate between either Woodhaven or Jamaica and Hammel. The direct route between Woodhaven and Hammel is across Jamaica Bay, but this part of the line is on a trestle most of the way, and was, therefore, extremely difficult to place in operation. For this reason the indirect route around by Valley Stream was used until the next day. Of course, while these repairs were being made to the electric transmission lines, steam locomotives were used to haul as many of the regular trains as possible.

While it is impossible at this time to give a detailed list of all the trouble, the following gives some indication of the extreme violence of the whipping action of the wires: Burned and misplaced cross-arms, 11; broken insulators, 30; broken ties, 99; wires burned in two, 1; wires badly burned but not severed, 1.

A Code for Better Lighting

IV

Believing that the proper illumination of railway offices, depots, shops, freight warehouses, docks, etc., is a most important factor in preventing accidents, in producing greater accuracy of workmanship and in increasing labor efficiency, we are reprinting, in short, readable articles, a Code of Lighting, prepared by committees of the Illuminating Engineering Society. This code is a practical summary of information pertaining to the illumination of shops and other work places.

The first article appeared in the January issue.

Section VII. Various Locations Illustrated.—Figs 3 to 9 inclusive are given to indicate how the problem of adequate illumination has been solved in a number of actual instances, and the following notes apply to some of the considerations involved.

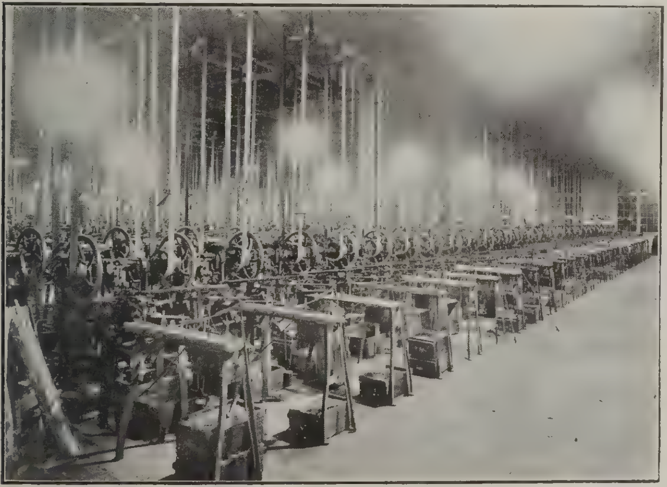


Fig. 3—Night View of a Rather Low Factory Section Showing 250-Watt Tungsten Lamps Mounted 12-ft. Above the Floor. Note the Original Individual Lamps Over the Machines.

There are two main items to consider in deciding for or against high candlepower lamps for the factory or mill. First, how high are the lamps to be mounted; and second, will the light at any given point on the machines or other operations be satisfactory if it comes from a few lamps or should it come from many sources? If the ceiling or overhead construction is under 16 ft., lamps of high candlepower can hardly be used in sufficient numbers to produce uniform illumination over the floor space. If they are to be mounted at a height between 16 and 25 ft., it is largely a question of whether light from a relatively few lamps will produce satisfactory results. For mounting heights over 25 ft., lamps of high candlepower possess some advantages, chief of which is their large volume of light for given energy consumed, always provided the light is effectively directed towards the floor.

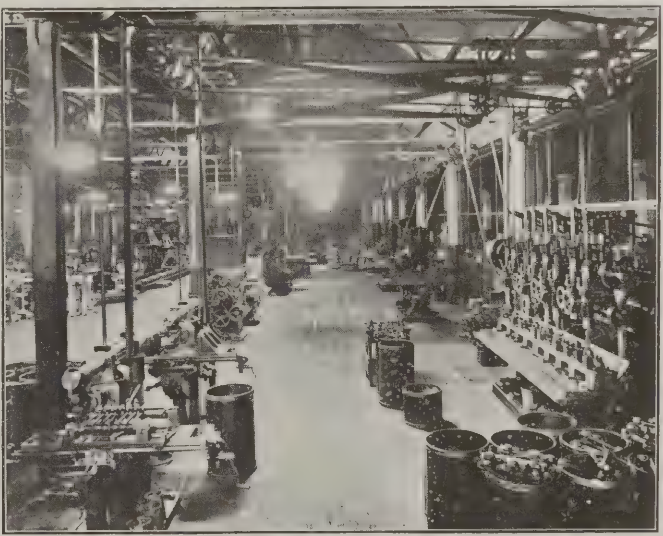


Fig. 4—Night View Showing Mercury-Vapor Lighting in Low Factory Section. The Lamps Are About 12-ft. Above the Work. Note the Comparative Absence of Shadows.

Three Groupings.—These three groupings by mounting heights are conveniently shown in Figs. 10, 11, 12 and 13. A single shop bay with a ceiling height of 12 ft. is shown in Fig. 10 as typical of the first grouping. The single high candlepower lamp furnishes approximately the same amount of light to the machines as do the eight small lamps. Note, however, that the illumination from the large lamp is not nearly as uniform as that from the small lamps, although the spacing of both the small and the large lamps as represented in this illustration is typical of many actual installations. Note also, that the shadows cast by the large lamp at certain portions of

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*Code copyrighted by the Illuminating Engineering Society.

the floor space must be so marked as to make the illumination it furnishes very inferior in this respect to the illumination from the smaller lamps, because of their larger number.

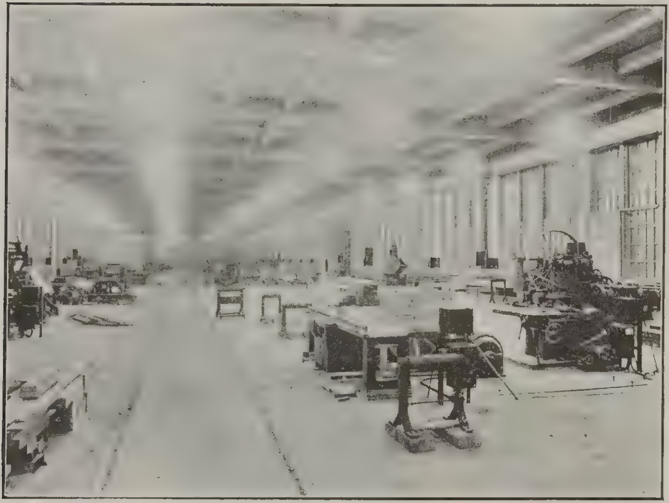

Fig. 5—Night View of a Planing Mill Showing an Installation of 250-Watt Tungsten Lamps with a 16-ft. Mounting. Note the Excellent Distribution of the Light and the Comparative Absence of Shadows. The Photograph also Shows the Cheerful Effect of Light Colored Walls and Ceiling. This is a good Example of the Overhead Method of Lighting.

Here, if the number of large lamps for the given floor area be increased in an endeavor to make the illumination more uniform and to reduce the shadows, the expense, as compared with that for smaller lamps, makes the large lamps a very unfavorable proposition. These two features are the basis for stating that, in general, large lamps are not desirable for mounting under 16 ft., and an analysis of conditions, together with a careful and unbiased comparison with the illumination produced by smaller lamps, will nearly always bear out this conclusion.

Fig. 6—Night View of a Boiler Shop

Second Grouping.—In Fig. 11, a 20 ft. ceiling has been selected as typical of the second grouping, a single shop bay being shown. Here the work is assumed to be rough assembly, mostly on horizontal surfaces, and the single high candlepower lamp, besides giving more nearly uniform illumination, because the light is distributed more broadly due to the increased height, is correspondingly more satisfactory as to shadows produced by the large lamp in the preceding illustration (Fig. 10), on account of the improved direction in which much of the light reaches the work. In this case, the arrangement of both large and small lamps is typical of many existing installations.

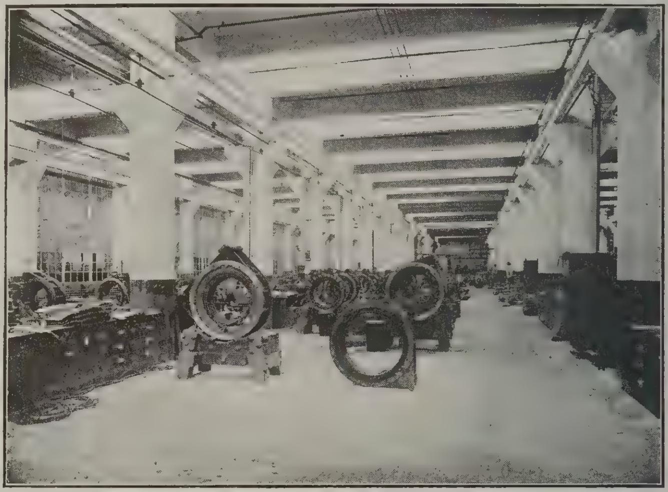

Fig. 7—Night View of Factory Section with Relatively High Mounting of 250-Watt Tungsten Lamps, Which Are 20-ft. Above the Floor. Note the Excellent Distribution of the Light and the Shielding Effect of the Girders Which Serve to Reduce the Glare When Looking Down the Aisle. The White Walls, Columns, Girders and Ceiling Also Add Greatly to the Efficiency of This Installation.

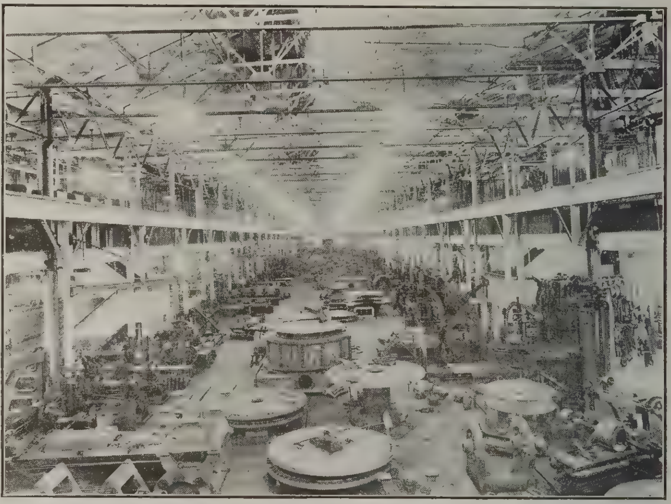

Fig. 8—Night View of Arc Lamp Installation with 40-ft. Mounting for the Two Center Rows of Fixtures and 20-ft. Mounting for the Outside Rows.

In Fig. 12, however, although the height is the same as in Fig. 11, the work is quite different, being conducted on the inside of large vertical tanks. It would obviously be impossible to perform this work by the light from the single large lamp as well as with that from the larger number of medium sized lamps, even if the actual amount of light from each was the same, on account of the poor direction of the light at certain positions of the work from a single unit in such a case. The medium sized lamps furnish approximately the same quantity of light and yet, no matter where the tanks may be placed, they will receive considerable light from the medium sized lamps directly over or nearly over them, at least far more than is apt to reach them from a single unit in every other bay.

For this second grouping of mounting heights, then, the large lamp may or may not be adapted, depending on whether the reduction of shadows is of much importance, as is the case in Fig. 12. The large lamp is, however, more likely to be satisfactory here than in the first case (Fig. 10), because of the better distribution of the light due to the higher mounting, a fact made evident in Figs. 10 and 12 on account of the decreased number of small lamps and the increase in their size made possible in Fig. 12 as compared with Fig. 10, where the mounting is lower. By the same line of argument, it can be shown that for higher mountings, large lamps are still more likely to prove satisfactorily. In Fig. 12, the number of large lamps might have been increased for the given floor area, but to have done so would mean that the cost for the lamps themselves and for the energy and upkeep to maintain them would be excessive.

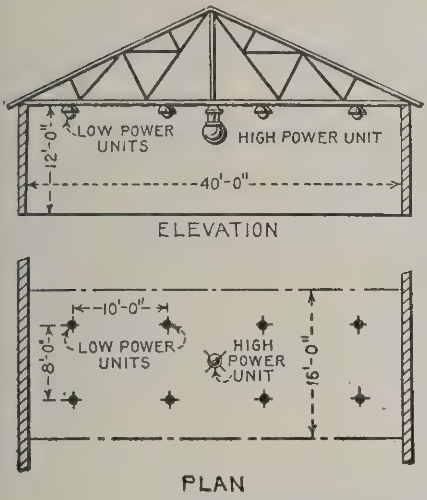

Fig. 10. Diagram Showing Alternate Schemes for Lighting a Low Factory Section. This Contrasts the Use of Large and Small Lamps for a Mounting Height of 12 Ft.

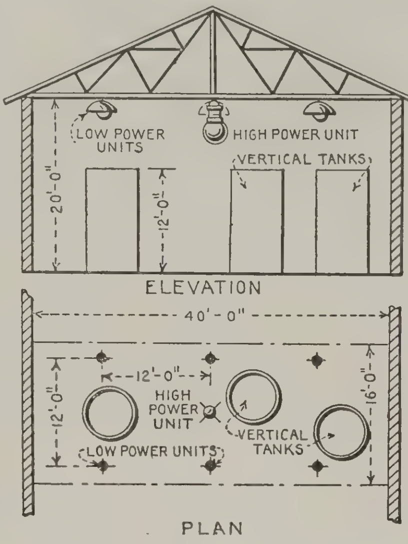

Fig. 11. Diagram Contrasting the Use of Large and Medium Size Lamps for Mounting Height of 20 Ft.

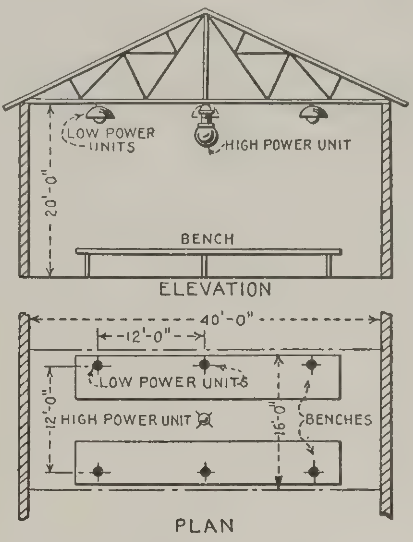

Fig. 12. Diagram of Same Factory Space Shown in Fig. 11, but with a Different Class of Work. This View Contrasts the Use of Large and Medium Sized Lamps for a 20-Ft. Mounting.

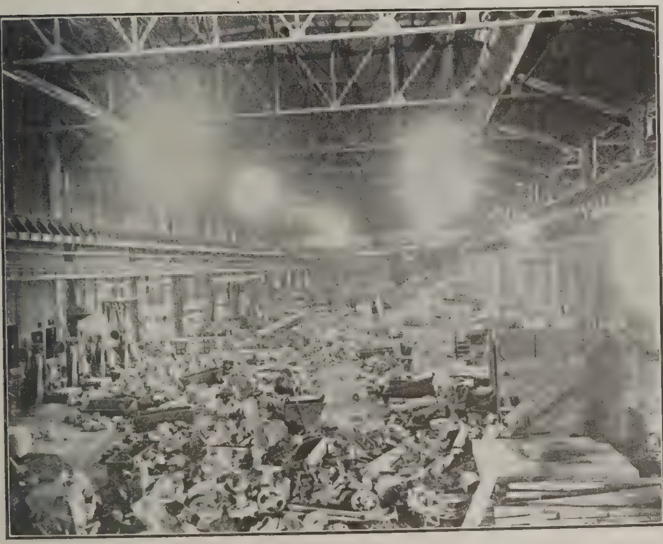

Fig. 9—High Section Showing the Fine Illumination Obtained from an Installation of Mercury-Vapor Lamps, Mounted Above the Crane.

Third Grouping.—In Fig. 13, the third grouping of mounting heights is shown with the lamps about 50 ft. above the floor. In this illustration the distribution of the light from the large lamps will be far more satisfactory both for flat and tall work than in the two preceding cases. It will be noted further that the increased height of the lamp causes the light to fall in such directions as to evenly distribute it over the entire floor space taken care of by this one lamp.

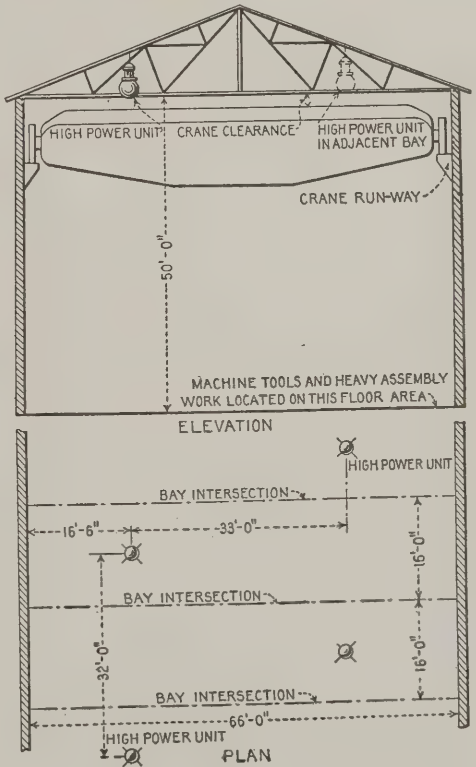

Fig. 13. Diagram Showing the Use of Large Lamps for a Mounting Height of 50 Ft.

Commutators and Commutation

By Gordon Fox

The foremost argument commonly presented against the use of direct current motors and generators is the necessary presence, in such machines, of a commutator. A commutator is inherently a delicate structure. It is made up of a large number of individual parts. These must be perfectly insulated from one another and from their supporting means. The whole must be mechanically rigid, it must retain a perfectly smooth surface by even wear of two differing materials, its component parts must not become dislodged the slightest amount, although subjected to repeated heating and cooling and to centrifugal forces, and the surface must continuously carry electric currents having destructive tendencies. This is a list of severe requirements and it is to be expected that an occasional commutator will go bad. But the manufacturers have perfected their designs to a degree such that direct current machines, if intelligently and systematically cared for, will furnish service comparable with that of the notably rugged induction motors.

The aim of this article is to discuss the ordinary causes of commutator and brush trouble, to suggest preventives and remedies and to outline methods for maintenance and repair.

Theory of Commutation

A commutator is a necessary adjunct to a direct current generator, because the voltages generated in the individual armature coils are alternating in sign or polarity as those coils pass under alternate north and south poles. To enable a direct voltage to be delivered the brushes must collect current from constantly changing sets of coils coming under the influence of fixed poles. Likewise, in a direct current motor continuous current can be introduced into moving coils under both north and south poles only by means of a commutator in such a way that their driving efforts will act cumulatively in a single direction to produce torque.

Each coil in a direct current machine passes alternately under positive and negative brushes. While a coil is under a north pole the current flows in one direction. When it is under a south pole the current flows in the opposite direction. The current reverses in each coil, while it is approximately midway between poles during the period that it is passing under the brushes. For ideal commutation while a coil passes under a brush the current in the coil should die down at a nearly uniform rate to zero value when the connected commutator bars are midway across the brush. It should then increase in the opposite direction uniformly to normal value attained by the time the coil passes from under the brush. This gives uniform current distribution over the brush surface.

Armature Reaction

There are several factors working against this condition. The first is armature reaction. Armature reaction causes a crowding and shifting of the field flux so that the coils midway between poles are not in a zone of zero flux. The resulting voltages generated are impressed upon closed circuits of low resistance. Consequently, if these coils be commutated there will be heavy short circuit currents. In addition, the tendency is for the current flow to remain in its original direction. Consequently the current distribution under the brush is not ideal as outlined. The current maintains its original direction under the greater part of the brush, changing sign and building up in the reverse direction at the last instant when the coil is passing from under the brush. The heavy short circuit current, combined with the crowding of the work current to the edge of the brush, causes high current density at that point. The sudden breaking off of this current causes arcing and spitting, synonymous with poor commutation. The effects of armature reaction are modified by shifting the brushes away from the midway position or "no load neutral." They then commutate coils located more favorably in the distorted field. The deficiency lies in the fact that the degree of field distortion and consequently the position of the coils best located for commutation changes with variation of load. The brushes must be set in a compromise position, shifted too much for no load conditions and too little for overload conditions. Moreover, shifting of the brushes changes the relative direction of the armature magnetizing force, thus affecting the speed or voltage of the machine and modifying its characteristics. The distribution of the flux under no load and full load conditions in a typical shunt motor without interpoles is shown in Figs. 1 and 2.

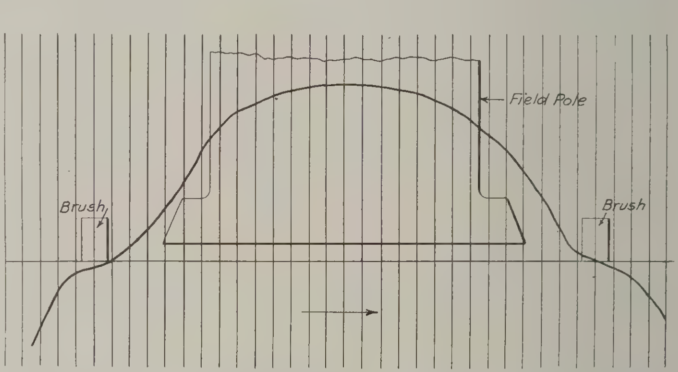

Fig. 1—Curve Showing Distribution of the Field Flux Under No Load Conditions in a Typical Shunt Motor Without Interpoles. Fig. 2 Shows a Distortion of This Field Due to Armature Reaction.

Self Induction

The second factor working against ideal commutating conditions under the brushes is the self-induction of the armature coils. Any coil surrounded by a magnetic circuit tends to continue a current once established. Consequently, if no corrective action is introduced, the tendency is for the current under the greater portion of the brush to remain in its original sign or direction, the reversal occurring at the instant the coil passes from under the brushes.

Interpoles

The two conditions adversely affecting commutation both need the same corrective influence, a commutating field approximately proportionate with the load and in a direction aiding reversal of current flow in the commutated coils. The interpole, now so commonly incorporated in direct current motors and in many direct current generators, meets this requirement effectively and greatly improves commutating conditions.

The commutator is the most sensitive member of a direct current machine. It is, therefore, first to suffer not only from faults in design, but also from exterior causes or defects in fields, armature or brushes.

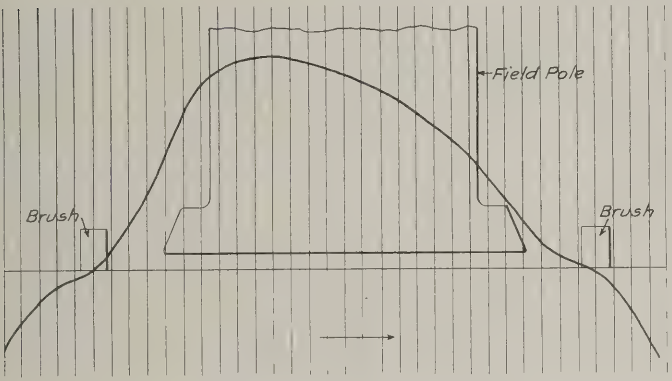

Fig. 2—Curve Showing Distortion of the Field Flux Caused by Armature Reaction at Full Load.

Field Effects

Faulty commutation may be traceable to three classes of field conditions, namely, limitations of design, mechanical defects and electrical defects.

The most common case of imperfect design leading to bad commutation lies in the ratio of armature magnetizing effect to field magnetizing force. If the armature effect is relatively too strong for the fields the armature reaction is very pronounced, the neutral shifts widely with changes of load and it is impossible to locate the brushes to obtain good commutation at all loads. Such cases can usually be bettered by increasing the air gap. This reduces the cross magnetizing effect by introduction of reluctance in its path. A stiffer field magnetizing force is also required to retain the original characteristics. Air gap increase can be accomplished in a machine with bolted-in poles by removing a shim if there be any, otherwise it is necessary to bore out the fields. As above stated, the excitation must be increased to overcome the increased reluctance of the magnetic circuit. If there is rheostat leeway in the original machine the increased field strength is easily obtained. Otherwise it is necessary to series parallel the fields as in Fig. 3, inserting a rheostat to govern the strength. Since the field current is increased by this procedure it cannot be adopted in cases where the field coils run normally very warm.

An effect similar to that of boring out the field is sometimes obtained by chamfering the pole tips so that they become quickly saturated, limiting the field distortion. In this case also it is usually necessary to strengthen the fields slightly to compensate for the increased reluctance incidental to cutting away the iron.

A non-uniform magnetic field will cause trouble, more or less serious. This may originate mechanically or electrically. Unequal pole spacing is a frequent cause. Where the pole pieces are cast into the yoke it is difficult to secure perfect spacing. Bolted-in poles are usually more accurate, since they are drilled in jigs. Pole spacing may be most readily checked by the use of large inside calipers. In machines with cast yokes blow holes may be present. These may increase the reluctance of portions of the magnetic circuit and cause unequal distribution. On rare occasions a casting is found in which the base of a cast-in pole does not properly weld with the cast metal, poor magnetic contact resulting. Such faults are usually detected in the factory, however.

The eccentric position of the armature in the magnetic field is responsible for not a little commutation trouble. This is most pronounced in armatures not provided with equalizers. The flux across the air gap is greater where the armature is nearer the poles and higher voltages are generated in these coils. The brushes then carry an equalizing current, which may be very great. The armatures of small machines should be kept accurately centered. It should not be considered that so long as a safe clearance is provided conditions are satisfactory. Mechanical clearance is not the sole purpose of the air gap. Large generators and motors usually have the armatures located purposely a little eccentric. The shaft is located 1/32 in. to 1/16 in. above the center in order that the resulting unbalanced upward pull may relieve the weight on the bearings and reduce friction. This practice is allowable to a moderate extent on the larger machines equipped with equalizer connections.

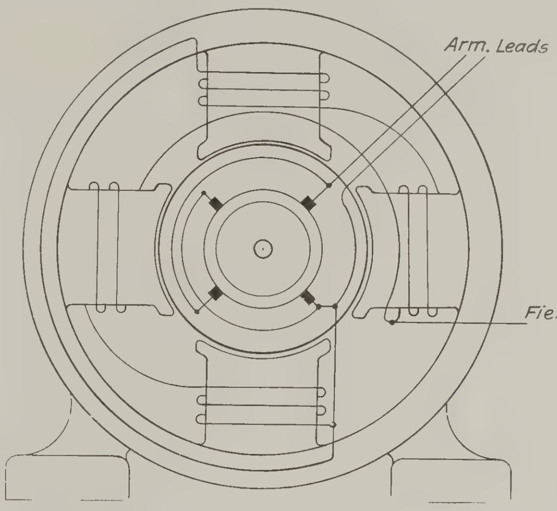

Fig. 3—Diagram Showing Connections for Connecting the Field Coils of a Direct Current Generator in Series Parallel for the Purpose of Increasing the Field Strength.

Electrical faults may cause a non-uniform field. A portion of the turns of a shunt coil or, sometimes, even an entire coil may be short-circuited and cut out of service. This may not affect noticeably the heating of the fields, but will affect the commutation as well as the speed or voltage. Such a fault can be detected and located by measuring the drop across the individual coils. A reversed coil will cause sparking and will materially increase the speed of a motor or decrease the voltage of a generator for a given rheostat setting. To detect a reversed coil excite the fields and span across adjacent pole pieces with an iron bar of suitable size. If the alternate poles are of opposite polarity, as they should be, the bar will be attracted strongly to the pole tips. Polarity can also be tested with a compass or a nail suspended from a string used as an improvised compass. This test is difficult to make accurately without removal of the armature. A compound wound machine may have one or all of its series coils reversed. There is, of course, a marked effect on the voltage or speed, usually leading to immediate detection. A single reversed series coil can be detected by means of polarity tests previously mentioned applied while the series field alone is connected across the line in series with a resistance. Both generators and motors are ordinarily cumulatively compounded and differential connection of the entire series causes weakening of the field under load with consequent greater proportionate effect of armature reaction, shifting of the neutral and sparking. A single bucking series coil will not materially affect performance, but will cause violent sparking under load, particularly at the brush stud affected. Reversal of the interpole windings on a machine so equipped will, of course, cause sparking, particularly under load. A deep humming sound also frequently accompanies this condition.

Armature Effects

A short circuit may occur between the individual turns of an armature coil or between two coils in the same slot. Since the armature coils are conductors cutting magnetic fields a short of any kind implies a closed circuit with a voltage generated within it. A heavy current results. This is usually sufficient to heat the affected coils so that they will smoke very quickly. Since an armature short circuit commonly indicates itself so plainly, sufficient time is not afforded for the commutator to be seriously damaged. The tendency is to heat up the commutator bars connected to the defective coils. They then become "high" bars and cause sparking.

An open circuit in an armature leads to severe sparking of a characteristic sort. Instead of the ordinary arcing under the brushes fine rings of blue or green fire run from brush to brush or completely around the commutator. After the machine is shut down the open coil can be quickly located since the mica segments between the commutator bars connected to this coil and its neighbor become severely pitted.

A poor connection between coil and commutator is similar to an open in its effects, but to a modified degree. Such a fault is due to poor soldering. The bad joint can be located by sending a current through the stationary armature and making a bar to bar voltage test. An excessive drop occurs across the defective joint.

Outside Causes

Conditions incident to the drive may cause periodic surges of current with consequent sparking. This may occur in a generator driven by a reciprocating engine having an irregular angular velocity. It may occur with motors geared to machines having cyclic loads causing repeated peaks at a given armature position. Pumps or reciprocating compressors are typical cases. A poor belt splice may have a similar effect. Geared machines displaying this trouble may be corrected by adding a hunting tooth to the gear so that the load peak occurs for differing positions of the armature. The trouble may be remedied on a belt drive by a slight change of pulley ratios. Cross currents between two or more machines in parallel may cause periodic peaks and intermittent sparking. These currents may be too short in duration to be detected upon the damped ammeters on the switchboard. Vibration is an enemy to commutation, making good brush contact difficult. Vibration is most commonly due to unbalance, but may be transmitted from the driven machine or may arise in a poor gear drive or a non-rigid mounting. An armature out of balance can be made fit by the addition of counterweights, well secured. The proper size and location for these may be determined by trial or by placing the armature on level knife edgeways and locating the heavy side.

Overloads may well be classed as "outside" causes of trouble. Steady overloads are likely to cause sparking indirectly through the mechanical effects of overheating as well as through increased armature reaction and greater currents to be commutated. Intermittent overloads may cause vicious sparking during their period sufficient to injure the commutator surface or to pit the brushes preventing the attainment of that glaze and polish so desirable for long commutator life. Motors repeatedly started and stopped or subjected to current surges arising from the use of dynamic braking may give trouble, although capable of rendering excellent service under more favorable conditions.

The Commutator

The surface of a commutator must be absolutely true and smooth if trouble is to be avoided. For, if sparking is started, either through mechanical cause or electrical cause, the condition becomes rapidly aggravated and deterioration of both commutator and brushes soon follows. High mica is a frequent trouble breeder. Any slight sparking may serve to burn away a little copper from one or more segments, leaving the mica projecting to a minute degree. The raised mica segments cause a slight separation between the commutator surface and the brushes. Across this gap the current must arc, showing itself as small, but numerous blue pin sparks under the entire brush surface. Arcing under the brushes must be distinguished from arcing at the edge of the brush. Arcing under the brushes is generally from a mechanical cause, such as high mica, vibration or light brush tension. Arcing at the edge of the brush indicates more commonly an unfavorable electrical condition. Sparking rapidly leads to blackening of the commutator segments. This may at first be confined to one or two bars. When these bars are under the brushes they shirk the load, since their contact is poor. The work current is thus shifted to the other brushes of the same polarity, which then carry more than their proportionate load. Burning and blackening are thus likely to follow at a number of equally spaced sectors, there being half as many spots as brush studs.

High Mica

High mica may be detected not only through its effect upon the operation of machines, but by examination of the commutator surface. Raised mica is at once evident if the finger nail be drawn across the segments. The most common remedy for high mica is undercutting. This process furnishes frequent relief in trouble cases and is becoming common practice. Special tools and attachments are now provided for this work in railroad shops and industrial establishments where enough motors are involved to justify the purchase of such equipment. Undercutting can be quite effectively done by hand tools, a hack saw blade or three-cornered file and a little experience being all that are necessary. Where commutators are undercut there is a liability of carbon dust collecting in the slots and short circuiting between bars. The rotation may suffice to throw out such particles by centrifugal force. In slow speed commutators they may accumulate. Occasional application of a brush prevents trouble from such causes.

(To be concluded in the May issue.)

Shop Motor Section

Transformers

J. H. Wickman*

XVII

The core loss of a transformer is the energy required to magnetize and demagnetize the iron core, due to the reversals of the current. Core loss is an important factor in the design of a good transformer and the purchaser should at all times keep this one point in mind, as this loss is constant and continues every hour the transformer is in operation, even when the transformer is not delivering current from the secondary. Therefore, a transformer having a low core loss has a high all day or commercial efficiency and low operating costs. The losses in a transformer as the capacity increases, assuming the same constants of design, increase approximately as the .85 power of the output. Therefore, with larger and larger units a point is soon reached where the losses are relatively low. In large power transformers, built for use in the central stations where the transformers are usually fully loaded, it is not so important to keep down the iron losses. In transformers of this type the iron and copper losses are made about equal. The importance of a low core loss is evident when the cost of operating the transformer is considered. A core loss of one watt per hour, assuming 24 hour per day operation and that it costs the central station one cent per k.w.h. to produce and deliver energy to the core of the transformer will amount to a yearly loss of 8.76 k.w.h. valued at 8¾ cents. It is evident then that a transformer with 50 watts less core loss than another of the same capacity will effect an annual saving of $4.37.

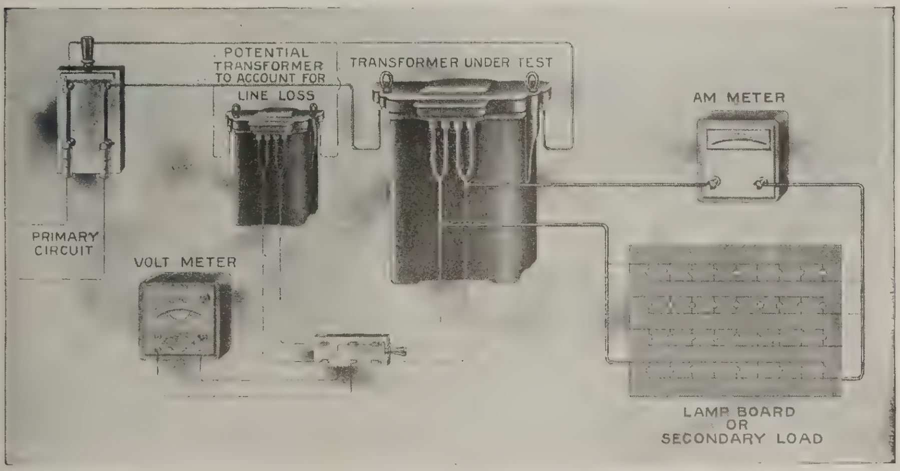
POTENTIAL TRANSFORMER TO ACCOUNT FOR LINE LOSS
TRANSFORMER UNDER TEST
AM METER
PRIMARY CIRCUIT
VOLT METER
LAMP BOARD OR SECONDARY LOAD

Fig. 47—Apparatus and Connections for Making a Regulation Test on a Transformer

Core Loss Test

The core loss of a transformer may easily be determined by the following method:

> Leave the primary leads open and clear from any contact and connect a watt meter in series with the secondary, which is controlled and supplied by a variable voltage transformer. Bring the voltage up to the value for which the transformer being tested is designed. The reading on the watt meter then will indicate the core or iron loss.

Copper Loss

There are copper losses in a transformer only when the transformer is delivering current. This loss, however, is affected by the general transformer design and the cross section of the copper used in its construction. Copper losses should be low at the average load so as to insure good regulation. The copper loss varies as the square of the current and may be calculated from the resistance of the conductors and the current flowing through them as follows:

> Copper loss in watts equals primary amperes squared, times primary resistance in ohms plus secondary amperes squared times secondary resistance in ohms.

The copper loss may be obtained by test by connecting an ammeter and watt meter in series with the high tension coils of a transformer, with the secondary coils short-circuited. A variable voltage transformer is used to supply the testing current. The current should be adjusted until the ammeter shows that full load current is flowing. A watt meter reading taken at this time will give the copper loss at full load.

Regulation

The regulation of a transformer is defined as the per cent. rise in secondary voltage, when the full rated load is thrown off, all other conditions remaining the same. For instance, if a transformer gives its rated secondary pressure of 110 volts at full non-inductive load, and the voltage rises to 115 volts when the load is thrown off (the primary voltage being kept constant) the regulation of the transformer by definition is:

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$$\frac{100\ (115 - 110)}{110} = 4.55 \text{ per cent.}$$

The regulation is controlled by the ohmic resistance of the copper circuits and by the magnetic leakage. Thus if the copper used in design is of large cross section with low ohmic resistance a close regulation can be expected. With close regulation the high efficiency lamps on the market can be used satisfactorily as a steady voltage means an increased life for any lamp.

Regulation Test

A test for regulation may be run on any transformer in the following manner:

Connect the transformer to be tested to the high tension supply circuit. A second transformer with the same or other known voltage ratio is also connected up as illustrated in Fig. 47.

By using a double pole, double throw switch, the volt meter can be made to read the pressure on the secondary of either transformer. Assuming the same voltage ratio it is evident that if both transformers are unloaded the volt meter will indicate the same pressure, but a gradual increasing of the lamp load up to the limit of the transformer capacity will be attended by a drop in pressure at the terminals. This drop can be read as the difference of the voltmeter indications and, when expressed in per cent. of full load secondary voltage, stands for regulation. The use of an auxiliary transformer is necessary to make sure of the high tension line voltage, as a large transformer under test would cause a primary drop when delivering power.

In all of the tests mentioned the primary current of the transformer may be taken as full load watts divided by primary volts.

Primary Cutouts

Transformers under 50 k.w. are nearly always provided with a primary switch cutout. Such cutouts are made up of two parts; one part is fastened to the pole or support on which the transformer is placed, and is connected in series with the primary leads. The other part is the portion to which the fuse is attached and is inserted into the first part, thus forming a complete cutout.

The general appearance of a transformer hung on a pole with the primary cutouts fastened to the top cross arm is shown in Fig. 48. The size of fuse to place in the transformer primary cutout may be found by the formula given in the last paragraph, allowing for 100 per cent. overload.

Primary cutouts are used to provide means for killing the transformer in case workmen wish to work on it and also to protect the transformer against short circuits, grounds, etc.

Potential Transformer Cutouts

Another type of cutout that is used for the same purpose but is only used in connection with potential or instrument transformers, is similar to an ordinary fuse block. This cutout is made of porcelain, takes a very long fuse of low amperage, seldom over 10, and is used with a maximum of 2,500 volts. This type of cutout is not weather-proof so is used inside exclusively.

Efficiency

The efficiency of a transformer is indicated by the following ratio: $\text{Efficiency} = \frac{\text{Power output}}{\text{Power intake}}$. For example, the full load efficiency of a 5000-watt transformer having 42 watts core loss and 90 watts copper loss would be:

$$\frac{5000 \text{ watts}}{5000 + 42 + 90} = 97.43\%.$$

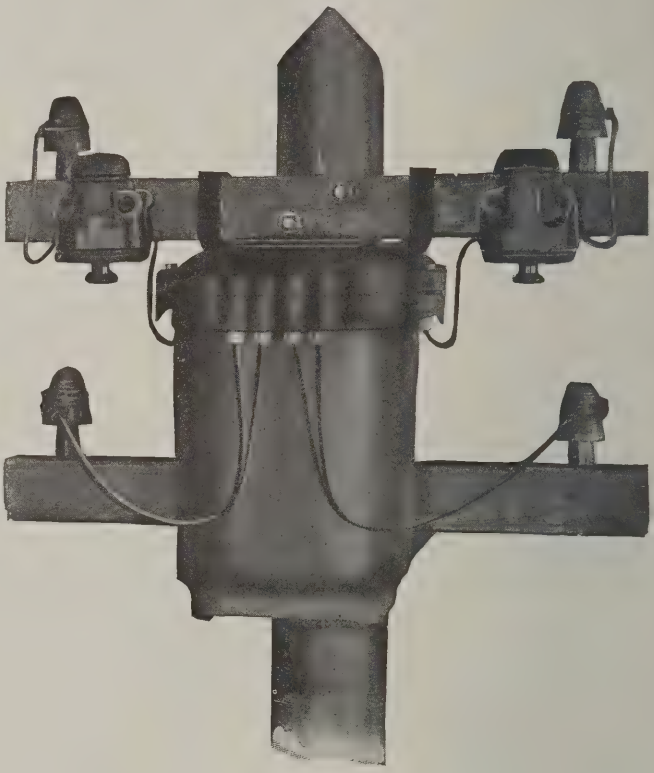


Fig. 48—Method of Hanging an Air-Cooled Transformer on a Pole. Note High-Tension Primary Leads and the Primary Cutouts on the Top Cross Arm and the Secondary Circuit on the Lower Cross Arm.

As the copper loss of a transformer is proportional to the square of the current, hence at:

¾ load — the copper loss is 9/16 of the full load copper loss;
½ load — the copper loss is 1/4 of the full load copper loss;
¼ load — the copper loss is 1/16 of the full load copper loss;

therefore, the ¾ load efficiency of a 5-k.w. transformer would be, ¾ of 5000 or 3750 watts; 9/16 of 90 = 50.625 watts.

$$\frac{3750 \text{ watts}}{3750 + 42 + 50.6} = 97.58\% \text{ efficiency.}$$

One-half load efficiency would be:

$$\frac{2500 \text{ watts}}{2500 + 42 + 22.5} = 97.46\% \text{ efficiency.}$$

One-quarter load efficiency would be:

$$\frac{1250 \text{ watts}}{1250 + 42 + 5.6} = 96.30\% \text{ efficiency.}$$

The all day efficiency of a 5-k.w. transformer which is loaded for 5 hours out of the 24 can be represented as:

$$\frac{5000 \text{ watts} \times 5 \text{ hours}}{(5 \text{ hours} \times 5000) + (42 \times 24 \text{ hours}) + (5 \text{ hours} \times 90)} \text{ or}$$

$$\frac{25000 \text{ watts}}{25000 + 1008 + 450} = 94.49\%.$$

Choice of Transformers

For transformers below 1000 k.v.a. capacity and 33000 volts potential, no particular type is recommended but above this voltage, however, the air blast type is not available on account of difficulties of insulation. Within these limits of capacity and voltage the choice of type must depend on the conditions affecting any particular installation. The self-cooled type requires the least attention, and in smaller sizes this type is especially desirable if water is scarce or expensive.

In larger sizes or where heavy loads are liable to occur, the water-cooled type is preferable. This type of transformer occupies less space and, as a whole, it will stand the most abuse. The air blast type may be desirable if there are large quantities of inflammable material present. This type occupies the least floor space but requires the most attention, due to the constant supply of air required. It is also more limited in overload capacity than either of the others, as it reaches its maximum temperature in a shorter time.

Relative Fire Risk of Transformers

The relative fire risk of the oil and the air blast transformers may be summed up as follows:

The oil transformer is set on fire with great difficulty. Any short circuit within the transformer itself will not set fire to the oil unless an arc is held in the oil long enough to raise the temperature of the total mass of oil to the combustion point, which would require some time and which would be impossible if the transformer was protected by a fuse or a circuit breaker. Even if the transformer was not protected the chances are that the leads would burn off before the oil would be raised to a dangerous temperature. If a fire should occur outside of the transformer case, hot enough to raise the oil to the combustion point, then a large mass of inflammable material is present to cause trouble.

With the air blast transformer there is much less inflammable material in the transformer itself, still if there is a short circuit within the transformer windings there are the best possible conditions for a hot fire, namely, considerable material under forced draft. However, if an air blast transformer should catch fire the top damper can be closed to smother it. If the operator is on hand there is a small fire hazard with either type.

Placing of Transformers

The placing of transformers depends upon where they are to be used and to a certain extent on the primary voltage.

Transformers of any type that are used around power houses and sub-stations are as a rule set on the floor in a room built for that purpose. Air blast transformers are usually set over a pit so that cooling can take place. This pit may often be a room that is air tight, or it may be a small space under the bank of transformers. In either case, all cracks must be cemented around the bottom floor line and ceilings to prevent leakage of air.

Transformers of small capacity for outdoor use are usually hung on poles similar to the one shown in Figure 48, the hangers hooking over the cross arms.

In the last few years it has also become standard practice to place banks of large capacity, high potential transformers, with their choke coils, lightning arresters, and disconnecting switches, outdoors on poles. Such installations are called outdoor sub-stations. The transformers are usually mounted on a platform between two poles, with the switches above or on adjoining poles.

Ratio of Voltages

As before mentioned the ratio of the primary and secondary voltages is the same as the ratio of the turns in the primary and secondary coils. For example, let us take a transformer with a name plate which reads, "Primary voltages 1100/2200 volts, secondary 110/220." This means that the ratio of the turns in the primary and secondary coils is 10 to 1, that is, there are ten turns in the primary coils to every turn in the secondary coils.

Transformer Connections

The following is copied from the standardization rules of the American Institute of Electrical Engineers:

Single Phase Transformers

Marking of leads:

"The leads of single-phase transformers shall be distinguished from each other by marking the high voltage leads with the letters A and B, and the low-voltage leads with the letters X and Y. They shall be so marked that the potential difference between A and B shall have the same direction at any instant as the potential difference between X and Y.

"In accordance with the above rule, the terminals of single phase transformers shall be marked as follows:

"(1) High and low voltage windings in phase:

A........B
X........Y

"(2) High and low voltage windings 180 degrees apart in phase:

A........B
Y........X

"To operate transformers thus marked in parallel, it is only necessary to connect similar marked terminals together (provided that the reactances and the resistances of the transformers are such as to permit of parallel operation).

Single-phase transformers with more than two windings.

Transformers possessing three or more windings (each being provided with separate outgoing leads), shall have the leads connected to two of their windings, lettered in accordance with the preceding paragraph. The remaining leads shall be distinguished from the others by a subscript. For example, transformers possessing four secondary leads connected to two distinct similar windings for multiple-series operation, shall be lettered as follows:

A........B
X........Y,
X′........Y′

This indicates that the low voltage winding consists of two disconnected parts, one part having terminals X Y and the other part having terminals X′ Y′. For multiple connection, X and X′ are connected together, and Y and Y′ are connected together. For series connection Y is connected to X′.

Neutral Lead.

"An outgoing 50% neutral tap lead should be lettered N.

Internal Connections.

"The manufacturer shall furnish a complete diagrammatic sketch of internal connections, and all taps and terminals of the transformer shall be marked to correspond with the numbers or letters in sketch."

Three Phase Transformer Connections.

"Three phase transformers ordinarily have three or four leads for high voltage, and three or four leads for low voltage windings. To distinguish the various leads from each other and to also distinguish between the various phase relations obtainable, the three high voltage leads should be lettered A B C and the three low voltage leads X Y Z. In addition, it should be distinctly stated in which of the three groups given in the following diagram the transformer belongs.

"The rules given above for single phase transformers in regard to neutral tap, also in regard to internal connections, are applicable to three phase transformers.

Parallel Operation of Three Phase Transformers.

"Three phase transformers, lettered in accordance with the above rules, will operate correctly in parallel, if at their rated loads, their percentage resistance drops are equal, and their percentage reactance drops are equal. It is furthermore necessary that the angular displacements between high voltage and low voltage windings shall be equal, *i.e.* that the transformers shall belong to the same group in the diagram. It is then only necessary to connect together similarly marked leads."

Connections for Single-Phase

The simplest transformer is a single-phase transformer such as shown in Figs. 45 and 48. Following are a few practical examples of how this type of transformer can be connected. All the connections necessary when installing this type of transformer are shown in Fig. 48. The primary leads are connected to the cutouts at the top, which are in turn connected to the line. The load circuit on the lower cross-arm is connected to the secondary leads as shown. In the illustration the secondary is connected for 110 volts, assuming a regular 10 to 1 ratio transformer and a primary voltage of 2,200. All light and motor circuits or other load which the transformer is to carry would be connected to the secondary circuit on the lower cross arm.

As heretofore stated, when using single-phase current for lighting purposes it is often desirable to use a three-wire system on account of the saving effected in line copper.

A single-phase transformer may be used to feed a three wire system by connecting the two inside secondary leads together and using them as a neutral and connecting the two outside secondary leads to the outside wires of the three-wire circuit.

If it was desired to transform 2,200 volts to 220 volts, the transformer used would have both of the primary coils and also both of the series coils connected in series. Such a transformer could be used on an 1,100 volt line also by connecting the two primary coils in parallel, that is, the lead marked A, Fig. 45, would be connected to B and the lead marked Y would be connected to X. If it was not desired to operate a two-wire secondary feeder system the secondary coils could be reconnected for a three-wire secondary system as explained above.

Two-Phase Connections

A two-phase system consists of two independent single-phases which must be kept apart. Therefore, whenever two-phase current is to be transformed each phase is handled exactly as if it were single-phase, the only difference being that two transformers are required instead of one, each of one-half the K. W. capacity for the same amount of power.

Whenever a three-wire, two-phase system is used one lead from each of the two transformers is connected together, on both the primary and secondary sides. In such cases the voltage ratio is the same as if four wires were used.

In the following diagrams one primary and one secondary coil only will be shown to represent a transformer. Thus in Fig. 50 the diagram shows a 4-wire, two-phase connection, in which A and B are the primary feeder lines. Should a three-wire, two-phase secondary service be desired, the lines (*a*) and (*d*) on the secondary side could be united together, then the voltage across (*b*) and (*c*) would be equal to the square root of 2, or 1.41 times that across (*c*) and (*d*), or across (*a*) and (*b*).

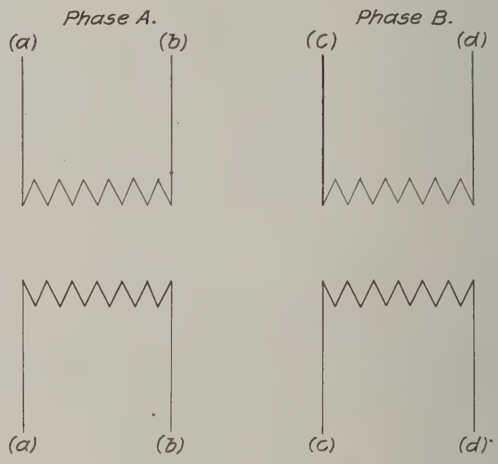


Fig. 49. Diagram Showing a 4-Wire, 2-Phase Connection for Transformers.

Transformers in Parallel

Often, after a transformer is installed, the load is increased to such an extent that it is seriously overloaded. It then becomes necessary to connect additional transformers in parallel with the one in trouble.

Two transformers built by the same company and connected just alike will, as a rule, be all right for paralleling, but they must be phased out in the same manner as when starting two alternators for the first time and the leads of the same polarity must be placed together. The method of phaseing out transformers and generators was described in a preceding article on alternating currents and will not be repeated at this place.

A simple way to phase out two small transformers is, when the load is off the line, to put a small fuse in series with one of the secondary leads of the transformer being added. If the connection is right the fuse will not blow, but if the connection is wrong it will blow and that will mean it is necessary to reverse the two secondary leads of the transformer being added, or if it is handier the primary leads can be reversed which will give the same results.

The above applies to all transformers, that is, they must be phased out before being thrown in parallel.

Single-Phase Transformers in Series

It is often desirable to use certain transformers on a line operating at twice the normal voltage for which the transformers were designed. For instance, suppose it was necessary to use some 1,100 volt transformers on a 2,200 volt line. In this case the primaries of two of the 1,100 volt transformers could be connected in series and connected to the 2,200 volt circuit. If the secondaries of both transformers were then connected in series, 220 volts would be available and if connected in parallel, 110 volts would be available.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 50

The Ampere Hour Meter Continued

All ampere hour meters should be calibrated or tested at least once a year. This, however, is not so difficult a proposition as one might suppose. All ampere hour meters are geared so that with full load current flowing through it in a discharge direction the meter will make 10 revolutions in just 36 seconds; with half load it would require just twice the time, etc.

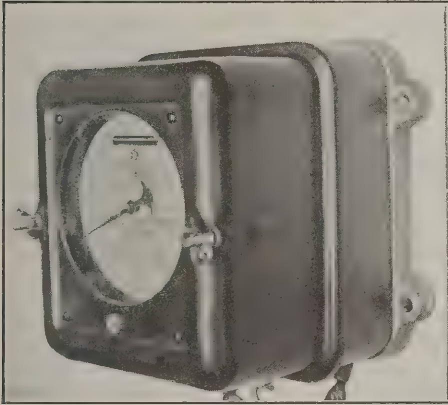


Fig. 253. Meter with Case Applied.

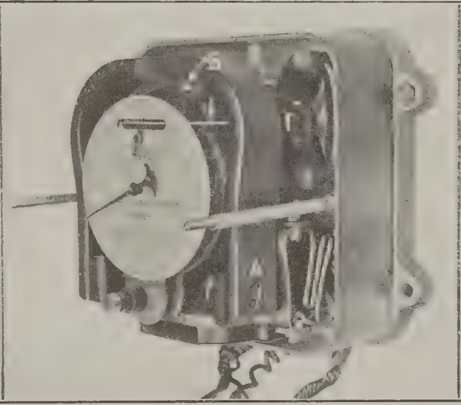


Fig. 254. Case Removed. First Step in Dismantling Is to Remove Horse-Shoe Magnet "A" by Loosening Screws "A" and "B."

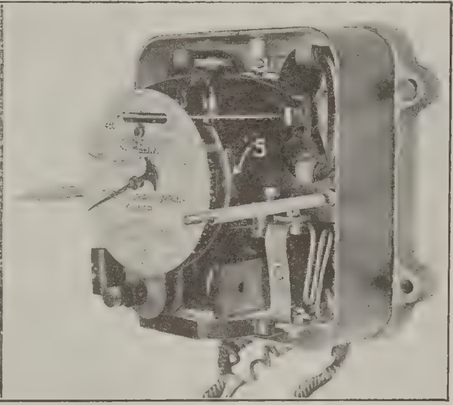


Fig. 255. Next Step, Force Out Locking Ears "S" Which Hold Dial and Gear Train, and Remove Dial. Then Remove Metal Strip "C" at Each Side of Meter.

In case it takes much over 36 seconds to make 10 revolutions at full load it would indicate that the meter is running slow, due to one of two causes: Either the magnetism of the horse-shoe magnets has become weakened or there is friction on the armature, its shaft or the damping disc or top jewel bearing. To determine whether the trouble is due to friction or weak magnetism, throw on a light load of 2 or 3 lamps; if the meter then fails to run at anything like proper speed—it indicates that there is friction; if it runs somewhere near proper speed, on the other hand, it indicates that magnetism of the main horse-shoe magnet has become weakened and does not give full torque to the meter disc.

This latter trouble of weak magnetism in the main horse-shoe magnet located at the front of the meter can be compensated for by lessening the retarding effect of the two damping magnets *W*, Fig. 258, located at the back of the meter. This can be done by loosening the set screw and turning the notched disc *X*, Fig. 258, so as to bring it a little closer to the magnets, lessening the air gap and short circuiting some of the magnetism away from the damping disc.

In this way the meter can be adjusted over a range of 10 or 15 per cent to run at proper speed even though the main magnet is weak.

To locate the friction troubles remove the case and first carefully examine the clearance between the damping disc and the damping magnet. If the disc is actually touching the magnet, or if there is any dust or iron filings on the tips of the magnets, the movement of the meter will, of course, be retarded. These iron filings and dust can be removed with a moist piece of paper.

It will be remembered that the wooden float attached to the armature and submerged in mercury, buoys up the armature shaft so that it is lifted entirely off the lower bearing and bears against the top jewel bearing with a slight pressure of about 1/10 of an ounce. It should be possible to force the shaft downward about 1/64 in. by a slight pressure with a pencil on the center of the damping disc. If there is no vertical movement of the armature shaft whatever it would indicate that the shaft is bound and this may be the cause of trouble.

If the trouble is not found here, however, it is probably in the armature chamber. To rectify this, the meter must be dismantled and the mercury removed and both mercury and armature chamber thoroughly cleaned of dust and dross, as will be explained later.

Dismantling the Meter

After removing the case, the large horse-shoe magnet should be taken off; this can be done by removing the two large screws holding the feet of the magnet (*A*, Fig. 254) and also the screw, *B*, holding the supporting frame at the top.

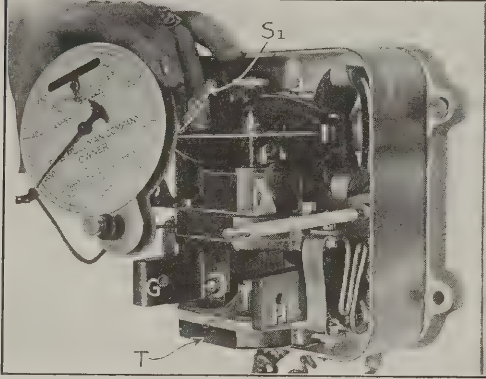


Fig. 256. Dial Removed. Resistor Element "T" Comes Off Next by Loosening Screws "E" and "F," Fig. 257.

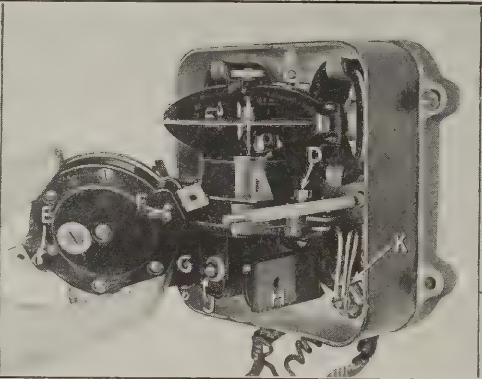


Fig. 257. Then Loosen Cap Screws "D" at Each Side of Armature Box and Remove Magnet Poles "G" and "H" by Loosening Screws "J." Armature with Frame and Damping Disc Complete Can Then Be Taken Out by Removing Screws "M," Fig. 259.

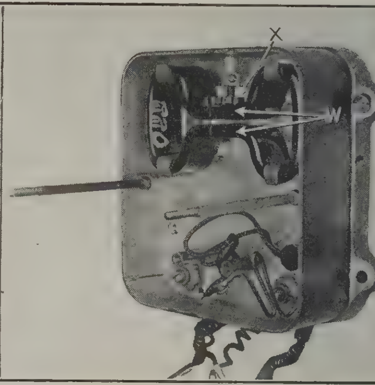


Fig. 258. Armature Element Removed Showing Damping Disc Magnets "W" and Adjusting Screw "X."

After removing this magnet be sure to lay it across a piece of iron to act as a keeper of the magnetism, otherwise the magnet will lose much of its magnetism, and when replaced in the meter it may not give satisfactory operation.

The dial and recording frame are next to come off, and these can be removed by simply forcing out the two locking ears, one of which is shown at *S*, Fig. 255 and the other at the opposite side of the dial. These are shown in the drawn out position, S_1, Fig. 256, with the dial off. The leads connecting to the contact points may be cut if necessary, although on the new type of meter these leads are carried to a small terminal mounted on the frame of the gear train and can simply be unscrewed.

The nickeled copper strips, *C*, Fig. 255, at each side of the meter connecting the resistor element at the bottom with the armature chamber at the center of the meter, should then be removed by loosening the bolts holding them. It will be noted that the lead at the right side is considerably heavier than that at the left side; this is to compensate for the difference in resistance between the coiled wire connecting from the shunt to the meter chamber on the right side and short, straight wire at the left side. In replacing these copper strips care must be taken to insure that the heaviest is placed on the right side, making the total resistance of the leads from shunt to resistor terminals the same on each side.

The variable resistor element, *T*, Fig. 256, located at the bottom of the meter should then be removed by loosening the screws, *E* and *F*, Fig. 257.

The two cap screws, *D*, Fig. 257, at each side of the armature chamber should then be loosened with a pair of pliers so as to release the clips holding the magnet pole pieces, *G* and *H*, below the armature chamber. The two large screws, *J*, Fig. 257, should then be loosened and the poles removed.

The entire armature and supporting frame with damping disc complete can then be taken off by removing the two supporting screws, *M*, Fig. 259, and also bending back the looped wire, *K*, Fig. 257.

With the armature element removed from the frame, the next step is to take off the upper part of the damping disc frame which supports the top jewel bearing of the armature shaft. This can be done by removing the two screws, *L*, Fig. 259, at either end of the frame. The damping disc comes next, which can be taken off by first loosening the two damping disc set screws, *N*, Fig. 259, which allows the disc and worm of the gear train to be removed from the armature shaft.

The six screws holding the hopper cap, *O*, Fig. 260, of the armature chamber, should then be removed and the cap taken off. This exposes the mercury in the armature chamber and the mercury should then be poured off in to a glass jar. Never pour this into a lead jar or tin cup, as the mercury will be contaminated by the lead or tin.

Next, after removing the dial supporting frame *Q*, remove the four screws, *P*, Fig. 260, which hold the armature chamber together. With these screws removed, the lower bracket of the armature chamber and the thin metal bottom plate holding the bottom jewel, *U*, Fig. 262, drops off.

The armature disc, *V*, Fig. 262, should then be removed and all of the mercury dross thoroughly brushed off from the armature disc and mercury chamber.

Cleaning the Mercury

Only chemically pure mercury must be used in the meter, inferior grades are sure to cause trouble. A good grade of mercury can be used for two or three years, but whenever the meter is overhauled the mercury should be cleaned. This can be done by making a cornucopia of paper so as to have a very small hole at the bottom; then pour the mercury into this cone and allow it to run out in a fine stream from the bottom. All of the dross will adhere to the sides of the paper cone and the mercury that runs through should be clean and bright. If the mercury after such treatment appears greasy or muddy looking, it probably contains lead or other impurities, and should be thrown away and new, pure mercury preferably that obtained from the manufacturer, should be substituted.

Assembling the Meter

It will be noticed that the thin metal plate forming the bottom of the armature chamber also carries the bottom jewel support. In order to make sure that this plate has not been bent out of shape, place it in the iron supporting frame of the armature chamber and hold it solid against the frame with the fingers; then place the armature disc with its shaft in the jewel bearing and spin it. There should be just enough clearance between the armature disc and the bottom plate to allow the disc to spin freely. If there is not enough clearance, that is the jewel is too low, when the meter is assembled and the mercury buoys up the armature shaft, it will be apt to lift the shaft out of the bottom bearing jewel; on the other hand, if it is too high it may bind the shaft when the meter is assembled. This bottom plate may be bent slightly with the fingers in order to bring the jewel bearing into about the right position.

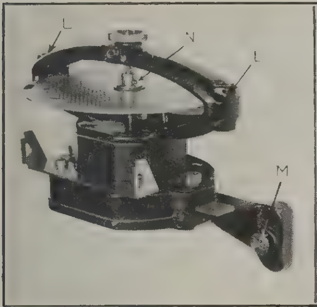


Fig. 259. Armature Element Complete as Removed from the Meter. Next Step is to Remove Top of Frame by Loosening the Two Screws "L." Damping Disc Hub Setscrews Should Then Be Loosened and Disc with Hub and Driving Worm Removed from Shaft.

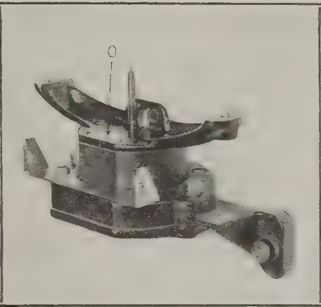


Fig. 260. Next remove Hopper Cap "O" by Loosening the Six Screws Which Hold it. The Mercury Chamber Will Then Be Exposed.

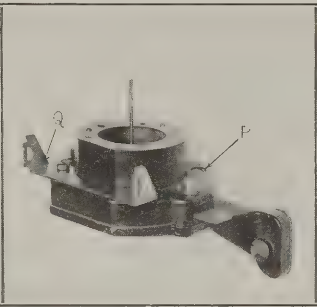


Fig. 261. Then Pour Mercury Into a Glass Jar (Never Use Tin, Copper or Lead Vessel) and Remove Dial Supporting Frame "Q" After Which the Bakelite Mercury Hopper is Removed by Loosening the Four Screws "P." Note the Dowel Pins to Hold Paper Gasket and Line Up Parts.

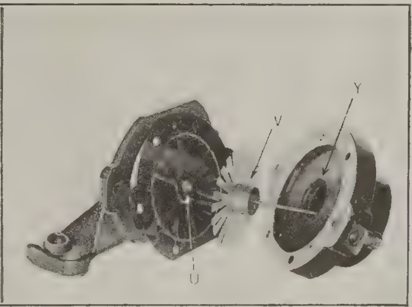


Fig. 262. Armature Chamber Can Then Be Taken Apart as Shown Exposing Armature Disc "V" and Bottom Jewel "U." The Circular Laminations "Y" Are a Roll of Iron Tape Which Completes the Magnetic Path Across the Poles. The Meter is Now Completely Apart and May Be Reassembled in a Reverse Order.

The armature box can then be slipped over the armature shaft and screwed into place. Be sure, however, that the paper washer between the bottom plate and armature box is in place, otherwise the mercury will leak out.

In replacing the mercury it is not necessary to weigh it, for a slight variation more or less makes almost no difference in the operation of the meter. Mercury should be added until the surface comes about even with the bottom ring of the inclined portion of the mercury hopper chamber, or, in other words, covering the wood float by about ⅛ in.

The hopper cap should then be screwed back in place with the 6 screws and the damping disc replaced on the armature shaft. The set screws, *N*, Fig. 259, however, should not be tightened until after the armature chamber is set in place, otherwise the damping disc may bind on its magnet. Be sure that the damping magnet tips are entirely clean and free from dust and iron filings before the damping disc is inserted between them. The armature frame screws, *M*, Fig. 259, should then be tightened, and the magnet poles, *G* and *H*, Fig. 256, set in place by means of their screws, *J*, be sure, however, that both the fibre washers and tubes insulating the magnet poles from the screws and also the mica washers and varnished cambric are in place insulating the poles from the resister element below. The resister element can now be added.

The two set screws, *N*, of the damping disc can now be tightened, thus locking the damping disc to the armature shaft. In doing this make sure that damping disc comes midway between the magnet tips, *W*, Fig. 258, when the meter is in an upright position, the armature shaft being then buoyed up by the mercury.

As explained above, there should now be a slight motion of the armature shaft in a vertical direction so as to allow the bottom bearing of the shaft to be entirely free. This movement should not be more than 1/64 in., and can be adjusted by loosening the thumb screw jewel bearing lock nut at the top of the shaft. With a screwdriver then turn the adjusting screw until the bearing is brought up tight against the shaft; this must be done very carefully so as not to injure the jewel; then back away with the adjusting screw ¾ of a turn, this will give about the right amount of end play to the armature shaft.

After replacing the leads connecting the resistor element with the armature chamber the horse-shoe magnet can be applied and the gear train set in place and locked by the ears, *A*, Fig. 255 and 256. The leads connecting up with the contact on the gear train should then be soldered and taped or screwed to terminal blocks and the meter case applied. The meter is then ready for calibration.

Every meter should be calibrated after being dismantled and cleaned. The calibration of meters of ampere hour meters has been discussed in the first part of this article.

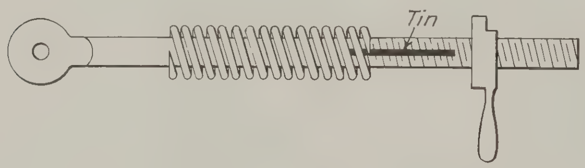
It is only within the past eighteen months that ampere hour meters have been extensively employed for controlling the battery charging of axle lighting equipment, so the subject is more or less new to all of us. Undoubtedly some new details of operation and maintenance will develop and we invite a free discussion of this subject in our Practical Stunts column. Through this interchange of ideas and experiences we will all benefit.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Holding a Stripped Nut

A simple method of holding a stripped nut on the adjustment spring rod of an axle lighting generator is shown in the accompanying illustration. A piece of No. 28 gage tin, ⅜ in. wide and about 6 in. long, is placed between the tension rod and the nut, as indicated. The nut is then screwed over this strip of tin, which is deformed to fit into the thread and offers sufficient surface to adequately hold the nut until a new nut can be applied. This practice has been found highly advantageous in cases of emergency.



M. R. Camois,
Electrician, Illinois Central, New Orleans, La.

A Convenient Drill Gage

Small drills about a shop are continually being mixed up, even when kept in a drill rack, and as the stenciled sizes on the shank are usually illegible some form of a drill gage should be kept in a handy place.

A convenient form of gage is made by taking a piece of steel ⅛ in. by 1¼ in. by 24 inches and drilling a line of holes ranging from 1-16 in. to ¾ in., including the sizes most commonly used. Below each hole stamp the size of the drill by which it was drilled.

This gage should be fastened to the wall near the drill press and drill rack by screws. A 1-in. block placed under each end will hold the gage 1 in. from the wall and provide plenty of room to stick the point of the drill through.

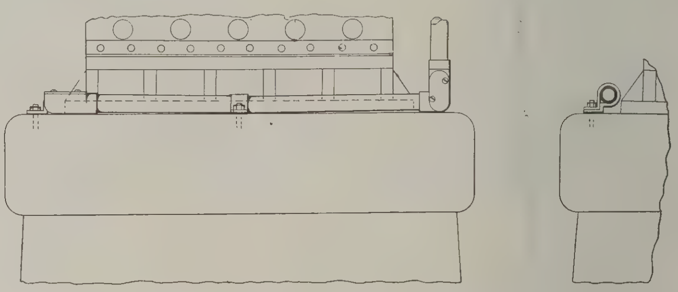
This gage is also handy for choosing a drill with which to drill a hole for wires, pins, screws, etc., and as it is fastened permanently in one place it can always be found.

C. B. Jennings,
1018 Western avenue, Topeka, Kan.

Conduit Installation

The accompanying illustration shows the common way of laying conduit along concrete piers or other outside locations. It will be noticed that there is great likelihood of collecting cinders and other dirt, which, after a rain-fall, become saturated with water. This water is held in the cinders for a long time, especially when the conduits are laid for railway bridge work, below the track on the piers. It is also well known that refrigerator cars run over these bridges with their brine drips open, the salt water from which is specially bad for the conduit as well as for the steel work, as it produces corrosion, and eventually holes in the conduit.

To prevent this difficulty and at the same time to increase the life of the conduits, the writer devised a simple way to eliminate the trouble by using a bracket as shown in the illustration, which raises the conduit about two inches from the pier. This bracket serves as a support as well as a conduit clamp and holds the conduit free in the air, thus giving the wind a chance to blow the cinders away.



The Side Elevation at the Left Shows the Common Way of Laying Conduit on Concrete Bridge Piers. The End View at the Right Shows How the Conduit is Raised Off the Concrete by Using a Special Clamp.

J. G. Koppel,
307 South Street,
Sault Ste Marie, Mich.

A Peculiar Case of Electrolysis

The accompanying photograph shows the outer and inner raceways of a U. S. L. brush holder carrier.

The car on which this carrier was mounted was caught with several others in the flood at Galveston, Texas, last September. All cars stood for several hours with their batteries and generators under water. In every case the brush holder carriers were deeply pitted as shown in the photograph. The brass brush holders were pitted in the same way, and in some cases the copper terminals at the batteries were eaten entirely away.

Is this pitting due to the action of the salt water or is it due to electrolysis caused by the discharge of the batteries through the wires and water?

The action seemed to be confined to the brush rigs and battery terminals only, other metal parts escaping. The balls in the brush rig bearings were mostly unharmed, although some of them were slightly rusted.

C. B. Jennings,
1018 Western Ave., Topeka, Kans.

Editor's Note

The pitting of the brush holder carrier on the U. S. L. axle generator, mentioned in the above letter from Mr. Jennings was evidently caused by electrolysis while the machine and the batteries were submerged in the salt water. The accompanying schematic diagram of the important wiring between the axle generator and the batteries gives the distribution of the current that would produce the pitting of the brush holder and the battery lugs as described. It is assumed that the water completely submerged both the generator and the battery but not the main switch, which was, of course, up in the car on the control panel. Under these conditions current from the battery would flow from the positive terminal, A, to the negative terminal, B, through as many paths as it could find. One path would be from A through the salt water direct to B. There would also be a certain flow of current between the intermediate cells and the extreme negative terminal. This current would pit and corrode the terminals of the battery as pointed out in Mr. Jennings' letter. Another path for the current and the one we are mostly interested in, would be from the positive terminal A through the salt water to the axle generator, through the iron parts of the machine to the brush holder carrier, out of this brush holder near the places where the brushes are attached, through the salt water into the brushes and on through the negative battery lead to the battery. In some cases the current would go directly to the commutator and the brushes, but the greater portion of it would go through the machine frame before it reached the brushes because the machine was enclosed.

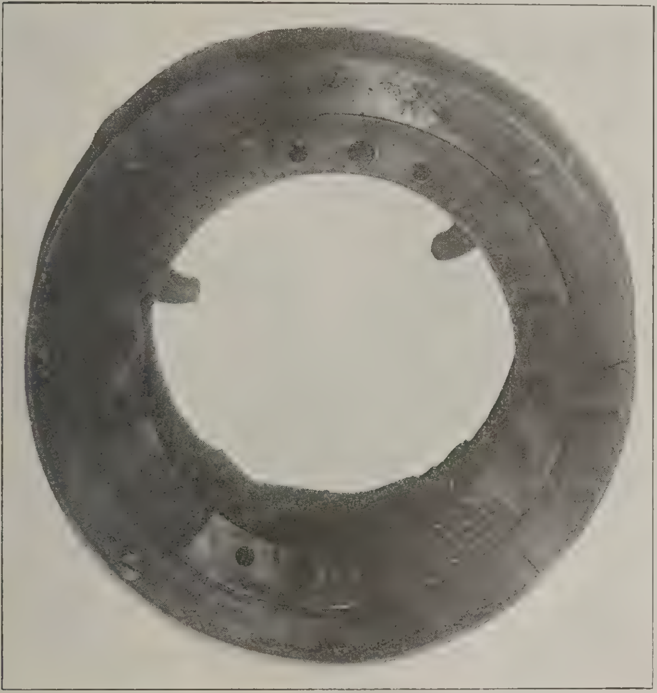


Fig. 1—A U. S. L. Brush Holder Carrier Which Shows Pitting Due to Electrolysis While Submerged in Salt Water During the Galveston Flood.

As the brush holder and brushes are insulated from the brush holder carrier, which is, of course, grounded or connected direct to the machine frame, the current that goes into the frame must come out at a point near the brush holder and go through the salt water for a short distance before it reaches the brush holders. In this case the points where the current left the frame of the machine to go into the brush holder were at the four points on the brush holder carrier between the brush holders. These points are shown in Fig. 1 as badly pitted. Such pitting would be expected, under the circumstances, because it is well known that electrolysis only takes place where current leaves an electrode in a solution of salt, acid or other chemical.

The brushes and the commutator were perhaps the only exposed portion of the main wiring exposed to the salt water besides the terminals of the battery itself, as all wiring was rubber covered and installed in conduit. If the terminals on the terminal block of the machine were exposed there was undoubtedly some pitting on the generator frame near this terminal block where the current left the machine frame to enter the nuts and bolts of the terminal. It should be noted that under the circumstances both brushes and the entire commutator of the axle generator were of the same potential, which was very nearly that of the negative end of the battery.

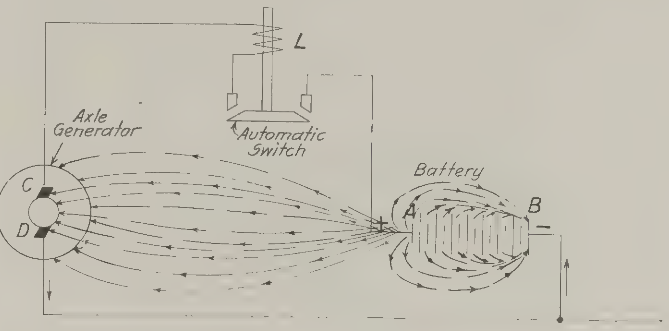


Fig. 2—Schematic Diagram of Main Circuit Wiring of U. S. L. Axle Generator and Battery Showing Flow of Current While the Equipment (except main switch) Was Submerged in Salt Water.

By referring to Fig. 1, it will be noted that the pitting at the bottom of the carrier is more severe than at the top.

This is probably because the lower terminals became submerged first when the water was rising and remained submerged longest when the water was falling; in other words, the total time that the lower brush holders were under water was greater than the time the upper brush holders were under water. It is also possible that the gas generated within the enclosed axle machine forced the water out of the machine until the pressure of the gas equalized the pressure of the water: in this way, the water lever in the machine might have been lowered to a point between the upper and lower brush holders, leaving the lower brush holders the only ones submerged and, therefore, the only ones which would be causing electrolysis.

New York Electric Car Lighting Association

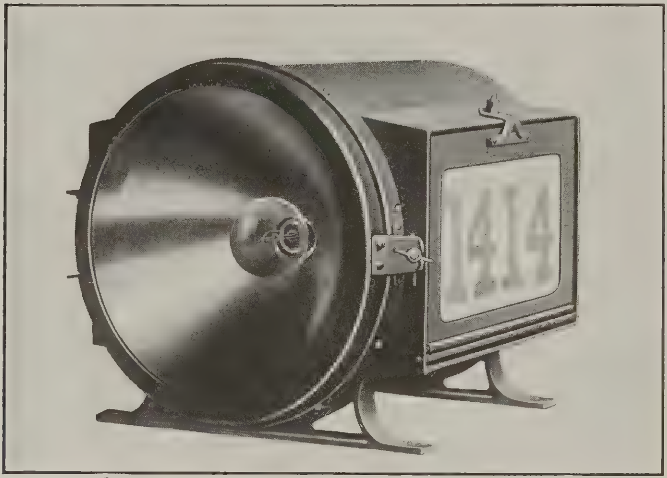
At the next meeting of the New York Electric Car Lighting Association, Jack Sutherland of the New York Central at Albany, N. Y., will give a talk on battery cleaning.

This is a most important subject and it is hoped that there will be a large attendance and that everyone will come prepared to ask questions and to enter into the discussion.

The meeting will be held in room 1030 of the Grand Central Terminal station and will be called to order at eight o'clock. Everyone should make it a point to be there on time.

Incandescent Electric Headlight Equipment

To meet the demands of the railways for incandescent headlight equipment the Schroeder Headlight Company, Evansville, Ind., has for the past few years given much attention to the development of this equipment. At the present time it has on the market three types of equipment, namely, the 6-volt turbo-generator, having a capacity of 150 watts, and two 32-volt turbo-generators having capacities of 350 watts and 1,000 watts, respectively. The 32-volt, 350-watt system has had the most extensive use up to the present time, it being the first of the incandescent equipment of that company to be placed on the market. It has already been made standard on some roads in view of the service it has performed. The following is a statement of the yearly maintenance cost of eight of these equipments reported by a road operating in the Middle West:

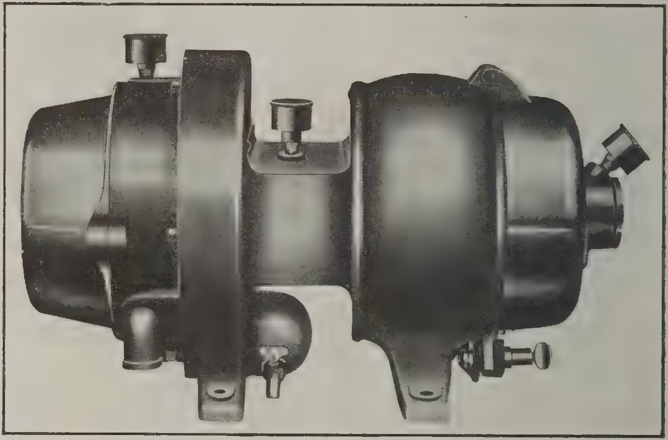


The Sunbeam Headlight

Repairs to turbo-generator*	$ .75
Labor and cost of lubrication	39.84
Incandescent headlight lamps	43.20
Incandescent cab lamps	8.51
Total	$92.30

This is an average of $11.54 per machine per year. This road uses 150-watt concentrated filament lamps on its road engines and 60-watt lamps of the same type at the front and back of the yard engines. The equipments are handled by the roundhouse machinist, who examines the brushes and generator about every 1,000 miles. Another road operating 212 headlights of this same type finds that with 100-watt, 125-candlepower lamps the requirements of the Illinois state laws are more than met. Tests of the 32-volt equipment made by this road with equipments which have been in service six months showed that the voltage did not vary more than 2¾ volts between boiler pressures of 100 lb. and 180 lb. This road also reports favorable maintenance costs, stating that they do not amount to one-half that spent for the arc light equipments.

The headlight equipments made by the Schroeder Headlight Company are all of the same general design, the only difference being in the size of the equipments. They will operate at any pressure from 75 lb. up. The 32-volt outfit weights 175 lb., and is 13 in. high, 24 in. long, and 12 in. wide. The body of the generator and the turbine is cast in one piece, insuring strength, rigidity and bearing alinement. Both the turbine wheel and the armature are fastened to the same shaft, which rotates on two sets of ball bearings, one located between the generator and the turbine wheel, and the other at the commutator end of the equipment. The generator is of the two-pole type and operates at a speed of 2,400 r.p.m. The commutator is made extra heavy, and will permit of several machinings before renewal is necessary. The armature can be removed quickly; the outside bearing housing is readily removed by taking out three cap screws and one retaining nut.



Schroeder 32-Volt, 350-Watt Turbo Generator

Steam from the boiler is admitted to the turbine through a governor valve that is automatically controlled by a centrifugal governor on the end of the turbine shaft, which, by regulating the valve opening, maintains constant turbine speed.

In designing this turbo-generator care was taken to keep all parts easily accessible for inspection or repairs, and to provide large bearings. A detachable outer shell at either end provides almost instant access to the governor on one end and the armature on the other. Further removal of a cast iron housing, which is held by set screws, gives access to the turbine wheel or armature. Lubrication is provided for by grease cups and large grease wells which surround the ball bearings, making daily attention unnecessary.

The six-volt turbo-generator system is the latest development. It has a capacity of 150 watts at 2,400 r.p.m. The weight is 120 lb., and the over-all dimensions, 14 in. by 19 in. by 15 in. high. The machine is built either with or without the throttling governor. When used without the governor the speed is kept practically constant by means of a reducing valve supplemented by a patented friction device, which prevents excessive speed. Grease is prevented from leaking out of the bearings by bushings having spiral oil grooves cut in them, which tend to return the lubricant to the bearings. This effects economy in lubrication and also prevents grease getting on the generator windings.

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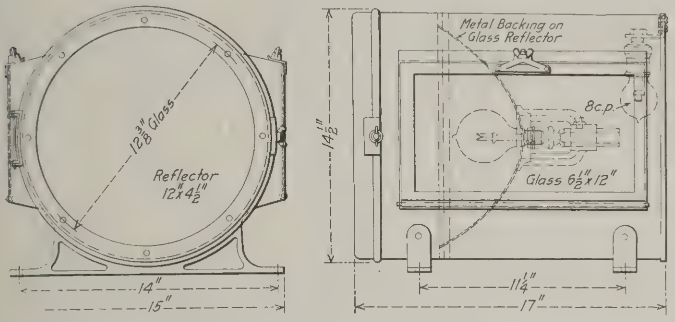
* This item was for carbon brushes, showing a perfect record for the mechanical construction of the machine.

This company also makes the headlight case and fixtures, which is known as the "Sunbeam" headlight. It is made for either a 6-volt or a 32-volt system, the only difference being in the incandescent light bulb. It has a heavy 12-in. mirror glass reflector slightly colored to make the light more penetrating. This never needs replating and does not tarnish. The lamp socket is adjustable, permitting the use and accurate focusing of any size incandescent round bulb or concentrated filament nitrogen lamp up to 250 watts. The distance at which objects can be discerned varies from 800 ft. to 2,000 ft., depending on the type of lamp used.



Details of the Sunbeam Headlight Showing the Arrangement of Reflectors and Lamps. The 8 c. p. Lamp at the Right Is for Illuminating the Number Plates

Number plates are provided at each side of the headlight, which are illuminated by a small bulb at night.

The headlight case is substantially constructed of metal; the doors are swung on heavy hinges and secured, when closed, by thumb screws, making it dustproof. It is supported by heavy iron brackets riveted to the body of the headlight and bolted to the support on the locomotive.

Headlights with other types of reflectors can be furnished in any special size and design having any size or type of number plate. This company also makes adjustable stands for incandescent bulbs for use in old type headlight cases, having large or small reflectors. These stands are adjustable to permit of properly focussing the lamp bulb in the reflector.

Three-Wire System With Rotary Balancer

By J. G. Koppel

The advantages in the use of the direct current, three-wire system are well known, and have led to its general adoption for the transmission and distribution of electrical energy from central stations, as well as in connection with the isolated plant service. In fact, there is no class of service having a fairly well divided lighting and power load, in which this system cannot be economically and effectively employed. The two voltages existing on the system, usually 110 and 220, meets the requirements of lighting and power service, respectively, in an ideal manner, inherent characteristics of lamps requiring the lower voltage, while motors are usually more economical and efficient at the higher voltage. The combination also affords a convenient means of operating variable-speed motors on a two-voltage system.

The majority of straight three-wire generators now in service are either of the Dobrowolsky type or one of its modifications. It may be regarded as an adapted two-wire generator, in which such a generator operates in conjunction with an ordinary auto-transformer with a single winding on a laminated core. The outer terminals of the transformer are connected to brushes which bear on slip-rings which are in turn connected to the armature windings at two or four points of opposite polarity, thus forming a single or two-phase connection to the armature. The neutral wire is taken off at the middle of the transformer. This is shown diagrammatically in the accompanying illustration, where two balancing coils "T" and "T1" and four slip-rings are employed. The connection between the slip-rings and the armature is two-phase.

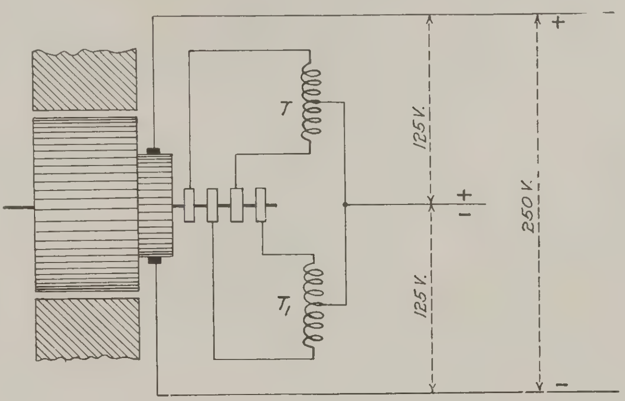


Fig. 1. Diagram of Connections for a Three-Wire Generator.

The coils of the transformer are wound on a laminated core and, therefore, have a high inductance. They are also subjected to an alternating potential from the armature, and, by reason of the counter electromotive force generated in them, the potential between the neutral wire and either outside lead of the generator will be one-half that between the two outside wires. The unbalanced current on the system may flow in either direction in the neutral, depending on which side is most heavily loaded.

In any case, the neutral current is divided in the balancing coil. This current meets with no opposition in the coil other than the ohmic resistance, and as it has opposite directions around the core, its magnetizing effect on the latter is zero. There is, therefore, no interference, from this source, with the choking or inductive effect of the balancing coil on the alternating current to which it is subjected.

In practice the auto-transformer, which is generally built in compact form and mounted in a cast-iron case filled with oil, can be placed in any convenient location, as the leads from it to the generator slip-rings can be of any desired length.

Personal Mention

W. H. Keirn

W. H. Keirn, who was chief electrician of the Philadelphia terminal division of the Pennsylvania Railroad, died shortly after nine o'clock, Tuesday morning, March 28, at his home in Philadelphia, and was buried in Altoona on Friday, March 31. Mr. Keirn was 51 years old and had been with the Pennsylvania practically all his life. He came from the Baltimore shops on January 1, 1910, to take charge of all electric light and power work for the Pennsylvania in the Philadelphia district, including the supervision of three power plants and of electric train lighting. Mr. Keirn took sick in Altoona on Monday and went home that afternoon, he ate a good supper that evening and seemed to feel better but later in the night he had a severe hemorrhage of the stomach from which he did not recover.

W. H. Keirn.

Mr. Keirn's untiring energy and devotion to duty made him a valuable officer for the company; his good-will and never failing humor endeared him to all of his associates; and his sterling qualities as a man commanded the respect of all who knew him. Those who were in daily contact with him miss him as an indefatigable worker, an able engineer and a devoted friend.

G. D. Smith

Mr. Geo. Drake Smith, for the past two years Supervisor of Agencies for the General Vehicle Company, Inc., has been appointed Special Assistant to Mr. Harrison G. Thompson, Vice-President and General Sales Manager, Edison Storage Battery Company. Mr. Smith will make his headquarters at the factory and main office, Orange, N. J.

Mr. Smith is widely known throughout the electrical industry, especially to the central station officials and operators who know him for his conscientious endeavor and successful effort in placing the electric commercial vehicle on a firmer footing in the United States and Canada.

G. H. Groce

George H. Groce, who has recently been appointed western sales manager of the railroad department of the Electric Storage Battery Company, with offices in Chicago, was born February 19, 1864, at Tarentum, Pa. He was educated in the public schools and entered railway service in 1880 as telegraph operator for the Pittsburgh & Lake Erie. From that time to 1897 he was consecutively telegraph operator, agent and train despatcher on various roads. From 1897 to 1899 he was superintendent of telegraph of the Baltimore & Ohio Southwestern system. He was then appointed superintendent of the Springfield division of the same road, and from 1902 to 1903 was southwestern agent of the Taylor Signal Company, with office at St. Louis, Mo. From that time to February, 1910, he was superintendent of telegraph and assistant to the general manager of the Illinois Central. He left that road to accept a position as assistant to the president of the General Railway Signal Company, leaving that position in December, 1912, to go with the Wright Telegraphic Typewriter Company as vice-president, where he remained until the end of 1914. During 1915 he was special selling representative for the General Railway Signal Company, from which company he resigned to go with the Electric Storage Battery Company on January 1, 1916, as above noted.

G. H. Groce

C. D. Sperry

The many railroad friends of Carleton D. Sperry will be interested to learn that he has been appointed to the railway sales department of the B. F. Goodrich Company. Mr. Sperry was editor of the *Railway Electrical Engineer* up to December, 1915, at which time he entered the employ of B. F. Goodrich Company. During his connection with the *Railway Electrical Engineer* Mr. Sperry had been very active, not only as a member of the staff of this publication but in association matters as well. In this latter connection his labors on some of the technical work on two or three of the more important committees have been of material assistance in advancing the work of these committees.

During his brief connection with the Goodrich company Mr. Sperry has been given the advantage of a most thorough training in all branches of the rubber industry. His many railroad friends, however, will be interested to learn that he has been recently assigned to work in connection with the engineering and sales problems of steam railroad equipment under C. M. Woodruff, manager of the railway department.

Mr. Sperry is a graduate of the electrical and mechanical engineering schools of the University of Wisconsin. There are few young men who so well combine a thorough technical training, a full appreciation of the practical side of engineering problems and a pleasing personality that makes us all his friends—here's success to you, Carl!

S. W. Everett

On January 1, S. W. Everett resigned from the Atchison, Topeka & Santa Fe, where he has held the position of electrical engineer since February 1, 1914. Mr. Everett was born in 1858 and received an education in the public schools at Topeka, Kan., and at the University of Kansas at Lawrence, Kan., where he took a special course in electrical work. His first actual experience in this line, however, was with the Topeka Edison Company where he worked for a number of years. His first car lighting work was with the National Car Lighting Company in 1896. Shortly afterwards he was employed by the Consolidated Railway Electric Lighting & Equipment Company at Topeka in connection with the maintenance of their axle lighting equipment on the Santa Fe. Later, when this work was taken over by the Santa Fe, Mr. Everett entered the Santa Fe service on May 18, 1901, at Argentine, Kan., as axle light inspector. On July 1, 1904, he was appointed assistant electrical engineer. It is generally understood that Mr. Everett has reverted to his primeval state and has taken up farming as a vocation. As yet no one has been appointed to succeed him.

General News Section

A Correction

Your attention is called to an error on page 303 of the March, 1916, issue of the *Railway Electrical Engineer*, where, in answering the question "Is it possible to reverse the parts of a negative plate in such a case?" the answer is given as "No, it is not, because of the different material in the two plates; the positive plate being *iron* and the negative *nickel*." The latter part of this answer should read "—the positive being *nickel* and the negative *iron*.

Annual Electrical Night Meeting of the New York Railroad Club

The New York Railroad Club held its annual electric night at the Engineering Societies building in New York on Friday, March 17. E. B. Katte, chief engineer of electric traction of the New York Central, presided and George Gibbs, of Gibbs & Hill, consulting engineers of New York, presented the paper of the evening on the smoke abatement report of the Chicago Association of Commerce. Mr. Gibbs illustrated his remarks with lantern slides showing maps, diagrams, charts and photographs, taken from the million word report. An abstract of this report appeared in the December, 1915, issue of the *Railway Electrical Engineer*.

After Mr. Gibbs presented his paper the meeting was devoted to a general discussion in which several prominent railway electrical engineers and other engineers interested in the subject participated. William McClellan, consulting engineer of New York, said that he questioned the right of a city to compel any railroad or combination of railroads to stand the entire expense of a purely civic improvement, such as the electrification of the Chicago terminals for the sole purpose of eliminating five per cent of the gases pollution and four per cent of the solid pollution of Chicago's atmosphere would be. Mr. McClellan said that he agreed with Col. Prouty of the Interstate Commerce Commission, who maintained that a railroad performs its entire duty in transporting passengers and freight with minimum delay and reasonable comfort; that the magnificent passenger terminals, which have been erected in some cities, while forming dignified terminals to great railroad systems, are not absolutely essential to the transportation of passengers and would, therefore, more properly come under the head of civic improvements rather than legitimate railroad improvements. Mr. McClellan held that in the case of Chicago, the entire electrification of the railroad terminals as a means of reducing the smoke nuisance would, in the same manner, be classed as a civic improvement and the expense therewith should be borne by the city benefited. He said it might be claimed that the saving in operating expenses effected by electric operation would warrant the expenditure by the railroads. He then pointed out that the annual charge on the total cost of the electrification would be $16,946,-

436, and that the operating saving would be only $2,336,693, thus leaving an annual deficit of $14,609,743.

Mr. McClellan also called attention to the fact that the committee of the Chicago Association of Commerce, when compiling its estimate of the cost of electrifying the Chicago terminal, was undoubtedly impressed by the knowledge that the estimate would be subjected to the most searching scrutiny by those particularly interested in forcing such an electrification. For this reason, he said, it is reasonable to assume that the estimate as finally prepared is most conservative and would not, perhaps, cover the total cost incident to the complete electrification. Considering the magnitude of this work which would involve the electrification of 3,476 miles of track, a large proportion of which are in the form of complicated yards, and also considering the amount of reconstruction work necessary, such as regrading yards and tracks, terminal approaches and overhead crossings, it would be unusual if many extra expenses did not creep in that could not possibly have been foreseen. This is always true where the work is new and where it is carried on under new conditions, necessitating frequent changes in design and in construction.

Mr. McClellan pointed out that the cost of the improvement as estimated by the committee was held, by them, to be so great as to warrant their reporting the electrification to be financially impractical, and in calling attention to the probable conservative nature of this estimate, he said he intended not to criticize but rather to strengthen the committee's contention in regard to the financial impracticability of the undertaking.

C. H. Quinn, chief electrical engineer of the Norfolk & Western, brought out the fact that the locomotives engaged in suburban passenger service, contrary to public opinion, produced only 1.54 per cent of the visible smoke in the city while yard and transfer locomotives produced 15.03 per cent of the total. In other words, the service which had appeared so objectionable and which, no doubt. started the agitation for electrification really is not so great a smoke producer as the yard and transfer service about which little complaint was made, and that the per cent of the total smoke in the city produced by steam locomotives is exceedingly small as compared to other agencies.

It was the unanimous opinion of those who entered into the discussion that the investigation of the Chicago Association of Commerce committee on smoke abatement and electrification of railway terminals was the most comprehensive and complete work of the kind that has ever been attempted.

Changing Edison Batteries in Six Minutes

The eastern terminal of the New York, Ontario & Western Railway Company is at Weehawken, N. J., but the facilities for handling and overhauling storage batteries at that point are limited, because the company has trackage rights only at that point and does not own property on which they could erect a building of sufficient size to even store materials, such as distilled water, electrolyte or other material necessary in the maintenance of storage batteries.

The main shops of the New York, Ontario & Western are located at Middletown, N. Y., 78 miles from Weehawken, and here ample facilities are provided for cleaning batteries and other electrical equipment. It is at this point that the majority of the work on the electric lighted cars and the electric lighting equipment is done. Although passenger trains do not terminate at Middletown they stop there ten minutes for engine changes and general inspection.

Recently the Edison storage batteries in 12 cars required a complete overhauling and under the circumstances it was necessary to remove these batteries and replace them with good sets without taking the cars out of service. Because of the lack of space and facilities at Weehawken, it was decided to make these changes at Middletown. One car was taken out of service and placed at Middletown, its batteries were removed and thoroughly overhauled, and the cells were re-assembled, ready to be put back in another car. The change was made while the train was standing at Middletown. The battery was taken out of one car in the train and an overhauled set was put in and connected up. The average time for making this change on all cars was six minutes per car.

Rail Joints and Bonds

"Modern Practice in the Construction and Maintenance of Rail Joints and Bonds in Electric Railways" is the title of Technologic Paper No. 62 just issued by the Bureau of Standards, Department of Commerce. The paper is largely a compilation of information in the nature of data and opinions submitted by forty-two electric railway companies who answered inquiries sent out by the Bureau.

Analysis of the data shows that soldered bonds have been demonstrated to be unsuccessful and are now practically obsolete while all other types of standard bonds are capable of giving good results, but only when carefully installed.

Loose rail joints are shown to be the most prevalent cause of bond failures and, as a result, there appears to be a marked tendency toward the adoption of improved methods and materials in their construction. The adoption of various types of welded joints to take the place of the common bolted joint appears to be in progress in most of the larger cities. The whole problem of track bonding is shown to be in a state of evolution owing to new inventions and recent improvements in methods of construction and, as a result, complete standardization of these practices cannot be expected for some time to come.

The character of track bonding is determined largely by the necessity for good operation and the prevention of stray currents which have a corrosive action on underground pipes. Economic considerations are shown to be of secondary importance.

Copies of the publication will be sent free to those interested who apply to the Bureau of Standards, Washington, D. C.

American Electric Railway Engineering Association

The 1915 proceedings of the American Electric Railway Engineering Association has just been published in a volume of 623 pages. The proceedings contain a complete report of the thirteenth annual convention held at Native Sons of Golden West building, San Francisco, Cal., October 4, 5, 6, 7 and 8, 1915. The reports of the following committees are of especial interest to electrical engineers of steam railroads: Committee on Lightning Protection; Committee on Standards; Committee on Power Distribution; Joint Committee on Block Signals for Electric Railways; Committee on Equipment; Committee on Buildings and Structures; Joint Committee on Engineering Accounting; Joint Committee on Life of Railway Physical Property; Committee on Power Generation, and the report of the Committee on Heavy Electric Traction, which covers the Clearance Lines for third rail working conductor, a Definition of Third Rail Gage, the Protection of Contact Rail Where Protected Third Rail is Used, and a Study of Modern Electric Locomotives. The proceedings also contain the report of the Committee on Electrolysis.

Photometry of the Gas-Filled Lamp

The new high efficiency gas-filled lamp introduces variables not hitherto encountered in the photometry of incandescent electric lamps. This matter has been made the subject of a study by the Bureau of Standards, Department of Commerce, and the results thereof have just been published in Scientific Paper No. 264.

On account of the comparative broadness of the filament spiral and the dissymmetry of the filament mounting, there is considerable irregularity in the distribution of the light about the vertical axis. Consequently, when the lamp is rotated, as is commonly done in rating lamps at the factory, the light as seen in the photometer flickers so excessively as to render accurate measurements of candlepower practically impossible without the use of auxiliary apparatus. However, as is sometimes done, if two mirrors inclined to each other be placed back of the lamp, the flickering is so much reduced as to permit accurate candlepower measurements even at very low speeds of rotation.

But this expedient does not eliminate the most serious trouble causd by rotation. It was found that at constant voltage both the current consumed and the candlepower are different when the lamp is rotating than when it is stationary, the current changing in one direction and the candlepower always in the opposite direction; that is, there is a change in the operating efficiency of the lamp. Furthermore, this change in efficiency may be either positive or negative, depending upon the speed, and it is about twice as great when the lamp is rotating tip up as when it is tip down.

Fortunately, from the standpoint of photometry, there is for each lamp in either position a particular speed at which the current and the candlepower have the same values, respectively, as when the lamp is stationary. Hence, with the lamp rotating at this speed, its candlepower can be measured with accuracy in spite of its rotation. The speed for the above condition is practically the same for all lamps having the same number of loops in the filament; but, for lamps having different forms of filament mounting, it varies from lamp to lamp, being greatest for those having the smallest number of loops in the filament.

If the above precaution as to speed adjustment is not observed and lamps are rated while rotating at speeds ordinarily used in photometering vacuum lamps, the errors which enter may amount to as much as 1 to 2 per cent in current, or watts, in one direction, and as much as 15 to 20 per cent in candlepower in the opposite direction. Hence, the voltage found for a desired operating efficiency may be so much in error as to give a lamp on test at this rated voltage a fictitious life value three or four times as large as the lamp would give if it were operated stationary at a voltage corresponding to that efficiency which during the rating was only apparent. That is, the lamp may be given credit for a much longer life than it really deserves. On the other hand, the speed may be such as to cause errors in the opposite direction resulting in a lamp life much shorter than would be expected from the apparent efficiency rating.

Another peculiarity of the gas-filled lamp is that while it burns the blackening occurs, not all over the bulb in approximate proportion to the light distribution as in the vacuum lamp, but principally at the top of the bulb, because the volatilized material is carried upward by the gas. Hence, in making a life test, a true measure of the reduction in total light during the life of the lamp cannot be obtained, in the usual manner, by mean horizontal candlepower measurements, but by determinations of the total flux or mean spherical candlepower. This is accomplished most rapidly and conveniently by means of an integrating photometer, such as the Ulbricht sphere, in which the lamp is measured stationary, and thus all the complications arising from rotation are entirely avoided.

As to the cause of the variations observed in candlepower and efficiency when the lamp is rotated, it is concluded from the results of a number of special tests that the whole effect is produced by a change in the convection currents of the gas, a consequent variation in the temperature distribution in the bulb, resulting in a change in the resistance, and therefore a variation in the current and candlepower of the lamp.

Copies of the paper, which is entitled "Photometry of the Gas-Filled Lamp," may be obtained without charge by persons interested upon application to the Bureau of Standards, Washington, D. C.

U. S. L. Announcement

The U. S. Light & Heat Corporation, Niagara Falls, N. Y., has issued the following: The Safety Car Heating & Lighting Company alleged some time ago that the U. S. Light & Heat Corporation was infringing its Thomson regulator for car lighting. The United States District Court for the Western district of New York held that this patent was invalid and hence that the U. S. Light & Heat Corporation was fully justified in its use of the carbon disc regulator. The court held that this company, through its predecessors, had used the carbon disc regulator prior to the Thomson patent and that the patent did not cover any additional patentable feature. The Safety Company appealed from this decision to the Court of Appeals for the Second Circuit which court has recently affirmed the decision of the lower court, holding the patent invalid. The Safety Company attempted to obtain a rehearing before the Court of Appeals, but this hearing has been denied, so that the suit is finally settled in favor of the U. S. Light & Heat Corporation.

New Books of Interest to Railway Electrical Engineers

Pole and Tower Line for Electric Tower Transmission.. By R. D. Coombs, C.E. 272 pages, 162 illustrations, 6½ in. by 9¼ in. Bound in cloth. Published by the McGraw-Hill Book Company, Inc., 239 West 39th street, New York. Price, $2.50.

It is not the purpose of the writer to deal with purely electrical problems such as the relation of voltage and size of wires to the electrical characteristic of the line or with such very specialized matters as the design of insulators. The problem is rather to develop a clear perception of the application of the laws of mechanics to the case in hand. The following items are well covered:

Types of Construction; Loading; Wires and Cables; Designs; Wooden Poles, Steel Poles and Towers; Special Structures; Concrete Poles; Foundations; Protective Coating; Line Material; Erection and Cost; Protection and Specifications.

Trade Publications

The E. S. B. Constant Voltage Axle Lighting System.—Bulletin No. 154, issued under date of March, 1916, by the Electric Storage Battery Company, Philadelphia, Pa., describes in considerable detail the fundamental principles, the method of operation, details of construction and contains some performance records of the E. S. B. axle lighting system. The fundamental principle of the E. S. B. axle system is constant voltage as distinguished from constant current. The first part of the bulletin explains how this constant voltage control insures maximum battery life, maximum interval between cleanings, infrequent flushing, elimination of lamp regulators and the elimination of adjustment for varying conditions of operation.

The operation of the E. S. B. axle system is fully explained in part 2. The distinguishing feature of this system is the use of the Rosenberg type of dynamo where the main field is produced by a magneto motive force developed by the armature winding. It is explained how, by the use of this type of dynamo and by the use of the Wheatstone bridge method of field control, the pole changer and the lamp regulator are eliminated, as are also the danger from overload and reversal of polarity. This part of the bulletin also explains why it is not necessary to have any levers, pivots, carbon piles, vibrating contacts or moving parts (except in the automatic switch) on the control panel.

The details of the construction are thoroughly described in part 3. One of the figures in this part of the bulletin shows three views of the new body-hung suspension.

Some interesting facts regarding the actual operation of the E. S. B. equipment, as installed on various railroads, are given in part 4. These performance records are complete and instructive and are accompanied by operation curves, plotted from data taken under actual operating conditions.

A copy of this bulletin will be forwarded to any of our readers upon application to the Electric Storage Battery Company, Philadelphia.

Incandescent Headlights.—Bulletin No. 43800, just issued by the General Electric Company, illustrates and describes that company's incandescent headlights for street railway service. The headlights referred to are of three classes, namely, for slow speed city service; for moderate speed city and suburban service, and for interurban service. All of these headlights are arranged to use focus type Mazda lamps. The headlights can be furnished with reflectors made of aluminum, silver-plated brass, or with silvered glass mirror. The bulletin describes headlights which may be mounted on the front car dash or recessed; or may be transferred from one end of the car to the other at the end of a run, in which case the connections are made by suitable plugs and receptacles. The publication contains information relative to the selection of not only the proper headlight, but also of the incandescent lamp used with it.

Industrial Preparedness

At the sixth annual banquet of the Westinghouse Interests in the Pittsburgh District held under the auspices of the Westinghouse Club, Saturday evening, March 11, in the Fort Pitt Hotel, the principal speaker was Mr. Wm. L. Saunders, vice-chairman of the Naval Consulting Board, and chairman of the Board of Directors of the Ingersoll Rand Company, New York.

Mr. Saunders had chosen for his subject "Industrial Preparedness for Peace and War," and in the course of his remarks said that if the industrial strength of the United States became known, no foreign country would dare attack us. "We are the largest and richest of all industrial nations. This is generally admitted. The last census (1912) showed the wealth of the United States to be about one hundred and eighty-eight thousand million dollars; to-day it is probably two hundred thousand million dollars. The consumption of coal in the United States is five tons per capita—a larger coal consumption than that of any other nation. The per capita coal consumption of the great industrial nations, England and Germany, is four tons, while that of France is 1.6 tons, and Russia with its millions of population is only one-fourth of a ton. This means that our industrial wealth is enormous, and it is industrial wealth which offers the greatest protection to a nation in time of war. It is obvious that this industrial wealth cannot be utilized to full measure unless it is organized, and it is obvious that it takes a long time to organize a country so big as the United States, hence the importance of beginning now to place our industries in a position where they will respond quickly and fully to the needs of the government in case of trouble."

"This is a subject which should particularly interest Pittsburgh because it is one of our largest industrial cities. Being situated back from the exposed coast, Pittsburgh would naturally occupy a place of importance in time of trouble. The President of the United States has asked the five leading engineering societies, namely, Civil, Mining, Mechanical, Electrical and Chemical, to organize the industries of the country."

"A plan has been formulated by the Naval Consulting Board involving a directorate of engineers in each of the forty-eight states of the Union—this directorate to consist of five men, one from each of the societies mentioned. These men have been selected by their respective societies and will have the aid of all the other engineers in the states tabulating and co-relating our industrial resources."

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WE GUARANTEE, that of this issue 2,150 copies were printed; that of these 2,150 copies, 1,737 were mailed to regular paid subscribers, 144 were mailed to advertisers, exchanges and correspondents, and 269 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 10,200, an average of 2,040 copies a month.

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Semi-Annual Convention of the A. R. E. E.

The semi-annual convention of the Association of Railway Electrical Engineers will be held at the Hotel Denis, Atlantic City, N. J., June 16. Judging from the marked activity on the part of the various committees during the winter months, we are led to believe that this will be by far the most interesting and effective semi-annual convention which the association has ever held. Important subjects which will be discussed are, the new basis for rating incandescent lamps, anti-friction bearings for electric motors, standardization of crane motors, metal conduit specifications, arc welding, and compressed air equipment versus electric operated tools in railway shops, etc.

This will be only a one-day session, but as it comes on Friday it will give opportunity to the electrical men of the railroads to spend the following day making a study of the many exhibits on the convention pier of interest to electrical men. The Master Car Builders' convention will be held June 14, 15 and 16 and the Master Mechanics' convention June 19, 20 and 21.

The Atlantic City conventions are among the most important railroad conventions of the year. It is therefore hoped that a large number of electrical men will take advantage of the opportunities offered by the elaborate exhibits and the semi-annual convention of the A. R. E. E.

The annual convention at Chicago will be held in the La Salle Hotel, October 30 to November 3, inclusive.

Overhauling Lead Storage Batteries

"When should a lead storage battery be given a regular overhauling?" "Should it be cleaned at regular stated intervals, or should it be cleaned only when conditions warrant it?" This is a question of vital interest to all car lighting men because the battery is, without doubt, the heart of the car lighting equipment. If the generator breaks down, if a belt falls off, or if for any other reason the generating parts of the equipment becomes inoperative, there are good reasons to believe that the car will still reach its terminal without a light failure, the lights burning from the battery entirely. On the other hand, if the battery is far below its normal capacity, or if for any other reasons the battery should fail, a bad light failure is very likely to result. For this reason it is important that the battery should at all times be kept in good condition and up to full capacity. It is gratifying to note that car lighting engineers are realizing this fact more and more every day and are continually increasing their efforts to maintain their batteries in perfect condition.

As any battery will deteriorate slowly with use, mainly because of the accumulation of sediment at the bottom of the tank which finally reaches the plates and short circuits them, it becomes necessary to occasionally dismantle the battery and give it a thorough overhauling and cleaning. The frequency of these cleanings depends upon the work which the battery has been doing and the treatment it has received.

In some cases the frequent cleaning of storage batteries has been carried too far. In general, the most satisfactory method is to adhere to the rule that a storage battery should never be overhauled until it is absolutely necessary, and it is seldom necessary until just before the sediment is actually in contact with the plates. On some roads the practice is to overhaul the storage batteries at regular intervals, in some cases once every twelve months, in others every eighteen months, etc., whereas the time factor should be entirely disregarded and the actual condition of the battery should be taken into account in each case before it is decided to overhaul it.

It is easily possible to do a battery more harm than good when overhauling it; in fact, the less a battery is tampered with the better off it is and the longer life it will give. It is good practice to inspect batteries regularly, say once every four or six months, in order to note the condition of the cells and to see how fast the sediment is accumulating. Finally, when it is found that the sediment is very near the bottom of the plates, the cells so found should be sent to the shops and thoroughly overhauled, but in no case should a cell be washed until it actually needs washing. The ideal time to take a cell out for overhauling and washing would be the day before the sediment actually touches the plate. Such close work, of course, is impractical, but it is true, nevertheless, that to overhaul a battery much before this ideal time arrives is not only unnecessary and undesirable, but is expensive and should be avoided except in cases where unusual trouble has developed.

Standardization of Voltage for Electrification

Elsewhere in this issue appears an abstract of an article on High Voltage Direct Current Railway Practice presented before the American Institute of Electrical Engineers in New York on April 14. The author of the paper advocates the adoption of 5,000 volts as a standard trolley voltage for all future main line and suburban electrification, on the basis that that voltage is the logical maximum towards which modern development tends. The recommendation is also based on the satisfactory operation of the 5,000-volt experimental equipment on the Michigan United Traction Line, which equipment has been in service since June 1, 1915.

The presentation of this paper brought out a lively discussion on the part of many eminent engineers who were present. This discussion showed that while a high voltage for electric railways is desirable from a standpoint of economy in power distribution, it should not be forgotten that the first cost and the maintenance cost of the rolling stock is also most important. It is, of course, evident that the higher the voltage the more expensive will be the electric locomotives and motor cars and the more it will cost to maintain them. The entire problem resolves itself into choosing a voltage that will give an economical balance between the cost of the transmission system and the cost of the rolling stock, and until it is definitely proved that 5,000 volts will give this balance, in the majority of installations, it cannot be accepted as a standard. For this reason and in the light of the little experience that we have had with 5,000-volt equipment it does not seem that the time has yet come to consider this the standard voltage for heavy electric traction d.c. systems.

The real object of the paper in question was, no doubt, to urge the adoption, as soon as possible, of a voltage that will give the best results under all average conditions so as to reduce the first cost and cost of maintenance of equipment. By thus bringing this important question before the American Institute of Electrical Engineers the paper proved to be of real service to the art and to the profession.

Counting the Cost of Anti-Friction Bearings

The chief objection to a very general use of anti-friction bearings for electric motors will be found in the argument that their cost is prohibitive. There are many things to be considered, however, aside from the simple comparison of the first cost of an anti-friction bearing versus the first cost of a sleeve-bearing, for in designing a motor to be equipped with anti-friction bearings numerous changes may be introduced which will simplify construction, reduce the length of the machine, lessen the size of shaft necessary and even result in a reduction in the iron and copper required; but above all, in counting the cost, the added reliability and decreased maintenance cost of the anti-friction bearing must be considered.

Some of these points are at once evident, such as the decreased length of the machine, the smaller shaft, made possible by the shorter distance between centers of support; the elimination of bulky and expensive oil wells and oiling mechanism and the great reduction in air gap made possible by the non-wearing characteristic of the anti-friction bearings. By taking advantage of this latter point when designing induction motors, less magnetizing force will be required for the same output, which means a more efficient motor and a motor with a higher power factor, the latter being a point of considerable importance in railroad machine shops today.

In making a comparison purely on a basis of first cost, provided the whole story be told, it can be said that the cost of building motors with anti-friction bearings will undoubtedly come much nearer to the cost of sleeve-bearing motors than many manufacturers seem to recognize. As to the unknown quantity in the proposition, reliability and maintenance, the very satisfactory operation of over 8,000 ball bearing mounted axle generators in car lighting service, which operate under about the most severe conditions imaginable, have answered this point to the entire satisfaction of the electrical men of the railroads.

With a reliability record of about ten to one compared to previous service with sleeve bearings and a maintenance record of attention only once or twice a year, the argument would seem to be in favor of the anti-friction bearing for electric motors.

A New Car Lighting Belt Problem

The introduction of the body hung type axle generator has brought with it an entirely new operating condition for the axle generator belt to meet, difficult as the operating conditions of this service were in the past, due to water, snow, ice, dust, sand, flying ballast and excessive belt tension applied by careless inspectors. The change in alignment of the axle pulley in respect to the generator shaft on rounding curves now introduces a new complication which must be taken into consideration in selecting the belt best suited to operate in this service. In rounding curves the truck swings so that the axle pulley is carried sidewise and slightly away from the generator pulley, and at the same time the car axle is thrown out of alignment with the generator shaft.

This difficulty is overcome by putting a very heavy crown on the generator pulley and also by putting 2 in. bevelled flanges on both the axle pulley and the generator pulley. These flanges are bevelled at just the proper angle so as to give maximum freedom to the belt without causing the belt to climb the flange.

The standard 5 in. car lighting belt, which has operated so successfully in this service, where the generators are mounted on the car trucks, seems to have some difficulty due to the change in alignment on rounding curves.

It will undoubtedly be found, however, that a narrower belt, of three inches or four inches in width, will largely overcome this difficulty.

The Lumen Defined

The following definitions of the lumen may be of interest to those of our readers who are not familiar with this unit:

The lumen is the unit of a light flux and denotes the light radiating within one unit solid angle (steradian) from a point source of one candle. A unit solid angle or steradian is the angular space subtended at the center of a sphere by a portion of its surface equal to its radius squared. An entire sphere includes 4π or 12.5664 steradians and, therefore, a uniform source of one candlepower emits 12.7 lumens. The same number (12.57) also denotes the number of square feet on the surface of a sphere of one foot radius so that remembering the definition of "foot-candle" it is evident that the lumen may also be defined as the amount of light required to illuminate an area of one square foot to an intensity of one foot-candle. The latter definition is usually considered the more practical of the two.

Index for Volume VII

In order to adhere to the standard of the other Simmons-Boardman Company publications it has been decided to include in volume VII of the RAILWAY ELECTRICAL ENGINEER all issues from June, 1915, to December, 1916, inclusive. In the future, therefore, all volumes will include the issues appearing in the calendar year instead of the fiscal year. We believe that this arrangement will prove to be more convenient than having each volume close with the May issue, as it will now be possible to identify all volumes by years. The index for volume VII will, therefore, not appear until December, 1916.

Letters to the Editor

The Lumen Basis for Rating Incandescent Lamps

C. R. I. & P. R. R. SHOPS, SILVIS, ILL.

TO THE EDITOR:

Many are following with growing interest the discussion recently opened in the *Railway Electrical Engineer* on the proposed adoption of the "lumen" as the unit of luminous flux for the commercial rating of lamps.

This is a welcome step for the illuminating engineer, for he has been using the term "lumen" for the last several years. The rating of mean horizontal candlepower was first multiplied by the reduction factor to obtain mean spherical candlepower, and this in turn by 4π to obtain the total amount of light in lumens emitted by the lamp. With this value of lumens he readily determined intensity by applying an efficiency factor and dividing by the area in square feet to be lighted. The manufacturer has already made the preliminary calculations unnecessary by stating the total lumens in the lamp data.

It should also be a welcome step to the lamp consumer. The old rating really meant nothing to him, except as a poor comparison. It is easy, however, to make him see that it is total light, not intensity in a zone, about which he should be concerned. This is especially true because he is told to buy a reflector to direct the light where needed. This idea of total light, not intensity in a direction, shows that it would be an absurdity to change only to mean spherical candlepower instead of to lumens.

Referring to the discussion on this subject by Mr. J. R. Sloan in the April issue of the *Railway Electrical Engineer,* I think a correction should be made for the benefit of the readers who are trying to get an understanding of the new unit "lumens." Mr. Sloan defines the lumen as "the amount of light that will give one candlepower on the interior of a sphere of one foot radius." This definition is rather loose and as will be interpreted, is incorrect. It requires 4π lumens to give an intensity of one foot-candle over the entire inner surface of a sphere of one foot radius. For the benefit of the average reader I think the lumen should be defined as the amount of light required to illuminate an area of one square foot to an intensity of one foot-candle. A point source of one candlepower emits 12.56 + total lumens.

J. H. EDWARDS.

Comments on the Proper Basis for Rating Lamps

"There seems to me to be no argument against the lumen and it should be adopted as a basis for rating electric lamps. Mr. Sharp, Mr. Davis and Mr. Sloan, in your issue of April, give good and sufficient reason so I will not take further space to reiterate on the subject."—*C. R. Gilman, chief electrician, Chicago, Milwaukee & St. Paul.*

"It would seem to me that on the subject of illumination the 'pièce de resistance' is light and not power and while, for the reasons named above, I have been unable to read any arguments to the contrary, the development along the lumen lines would appear to be the correct one."—*W. S. Murray, consulting engineer, New York, New Haven & Hartford.*

"Our opinion is that the lamp should be rated on the lumen basis or on a similar basis that will give the true rating of the total light flux of a lamp."—*H. M. Warren, electrical engineer, Delaware, Lackawana & Western.*

A Correction

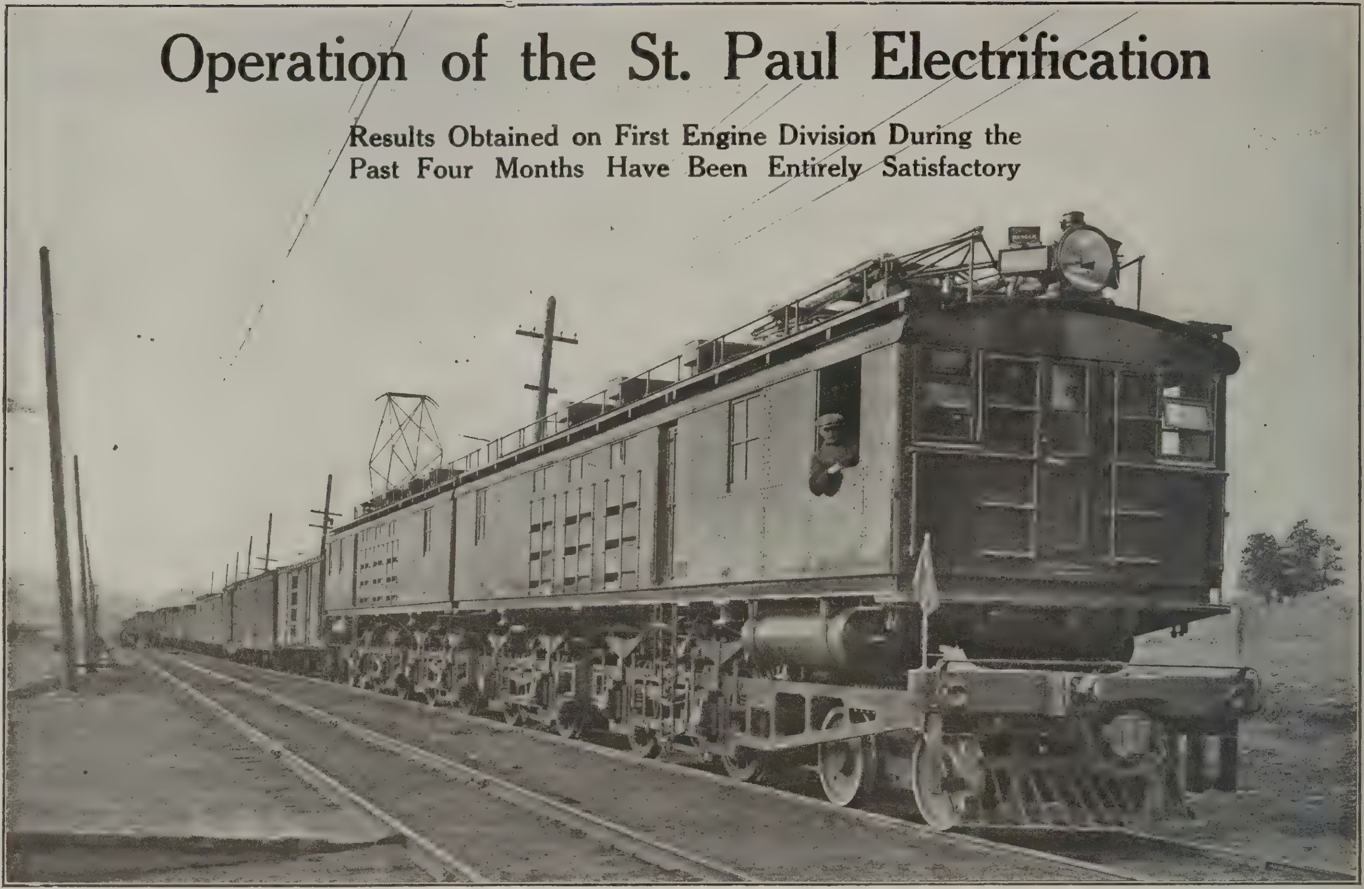
In the second paragraph of the second column of page 312 of the April issue of the *Railway Electrical Engineer,* J. R. Sloan defines the lumen as the amount of light that will give one candlepower at any point on the interior of a sphere of one-foot radius. As this definition may be misinterpreted, Mr. Sloan wishes it corrected to read, "the lumen is defined as the amount of light that will illuminate a square foot on the interior of a sphere of one-foot radius, to an intensity of one foot candle."

The most practical definition of a lumen is the amount of light required to illuminate an area of one square foot to an intensity of one foot candle, which means that a light source of one lumen will illuminate a square foot on the interior of any sphere to an intensity of one foot candle.

Mr. Sloan's object in using a sphere of one-foot radius in his definition was to simplify the problem of showing the relation between mean spherical candle power and the lumen.

Operation of the St. Paul Electrification

Results Obtained on First Engine Division During the Past Four Months Have Been Entirely Satisfactory



A 1,650-Ton Freight Train Regenerating on a 2 Per Cent Grade at Grace, Mont.

Since December 9, 1915, when the Chicago, Milwaukee & St. Paul's crack transcontinental "Olympian" was taken from Butte, Mont., to Piedmont by an electric locomotive the first engine division of the electrified zone has been in continuous electrical operation. Both the "Olympian" and the "Columbian" have been hauled by electric locomotives since the inauguration of electric service, but it was not until January that steam freight locomotives were entirely removed from the electrified division.

The electrification has, in every way, exceeded the expectation of both the railroad officers and the manufacturers of the equipment, and, considering that this installation is the first to use 3,000 volts direct current, the regularity of operation and the remarkable freedom from trouble with the locomotives and the catenary system has been extremely gratifying. It has been found that the contract capacity of the locomotive, which was 2,500 tons on a 1 per cent. grade with one locomotive at a speed of approximately 15 miles an hour can easily be exceeded, and as soon as the side tracks on the mountain division are made long enough to take care of the longer trains it will probably be arranged to increase the train tonnage to 3,000 tons over the mountains to 3,450 tons between Deer Lodge and the mountain and to 4,500 tons between the Bitter Root mountains and Deer Lodge, all with one locomotive, except that over the short heavier grades a helper will be used.

The mileage of the electric trains for 24 hours is said to be about 200 as against 114 by steam locomotives. Twenty-four steam locomotives—Mallets and other heavy types—have been released with only one-fourth of the electrification in operation, and the work is being done faster and cheaper with the nine electric locomotives.

The question of hauling capacity of an electric locomotive is perhaps not thoroughly understood by the steam locomotive operator. His chief concern is to keep the steam locomotive hot and make steam, while the electric designer so proportions the motors that they will keep cool with the assigned tonnage.

The electric motor should not operate at much more than 125 degrees Fahrenheit above the surrounding air, as higher temperatures will cause an unduly rapid deterioration of the insulation covering the copper conductors. Hence the somewhat baffling statement can be truly made that the electric locomotive will haul a greater tonnage in winter or cold weather than it will in summer, in this respect just the reverse of the performance of the steam locomotive.

Another point in the hauling capacity of the electric locomotive is that for short periods of time it will haul anything up to the slipping point of its drivers. Normally the tractive power of the electric locomotive is approximately 16 per cent. of the weight upon the drivers, but for short periods it can exert 30 per cent. and for one hour it can exert 20 per cent. of this weight. Illustrating this: A 2,300-ton train on the St. Paul was being taken westbound from Piedmont up the 2 per cent. grade with one locomotive at the head end and a helper at the rear end. The train broke in two, leaving approximately 2,000 tons on the head end locomotive. Instead of cutting off the bad order car it was decided to proceed up grade to the next station, and in this case one locomotive actually hauled 2,000 tons up a 2 per cent. grade without a helper. As this machine is rated at only 1,250 tons, the performance gives an idea of the tremendous overload which such a locomotive can haul for a short time. Continued operation at this heavy overload would, of course, result in the destruction of the insulation, or what is known as "burning out of the motor."

The electric locomotives, and in fact all of the electric equipment on the St. Paul, has been given a severe test during the past winter, which, because of the deep snow and the severe cold, was one of the worst in the history of Montana. It is reported that the electric operation during this period was conspicuous for its complete reliability and freedom from trouble. It is true that a regulator which is used in connection with the motor generator on the locomotive to supply low voltage current for lighting and control was not quite up to the capacity required, and therefore gave some trouble, and also that some other minor troubles were experienced with a few of the cam operated switches. None of these troubles were serious, however, and it proved to be a simple matter to overcome them. One of the surprising operating conditions met with was the frosting of the electric locomotives when they were taken into a steam locomotive roundhouse after operating in a temperature of from 20 to 30 degrees below zero. It was found that frost and ice would collect on all parts of the electric locomotive in a surprisingly short time. This trouble, of course, would not be so noticeable and, in fact, would probably not occur in a roundhouse which did not house steam locomotives. For this reason when the division is entirely electrically operated the trouble from frost should be eliminated.

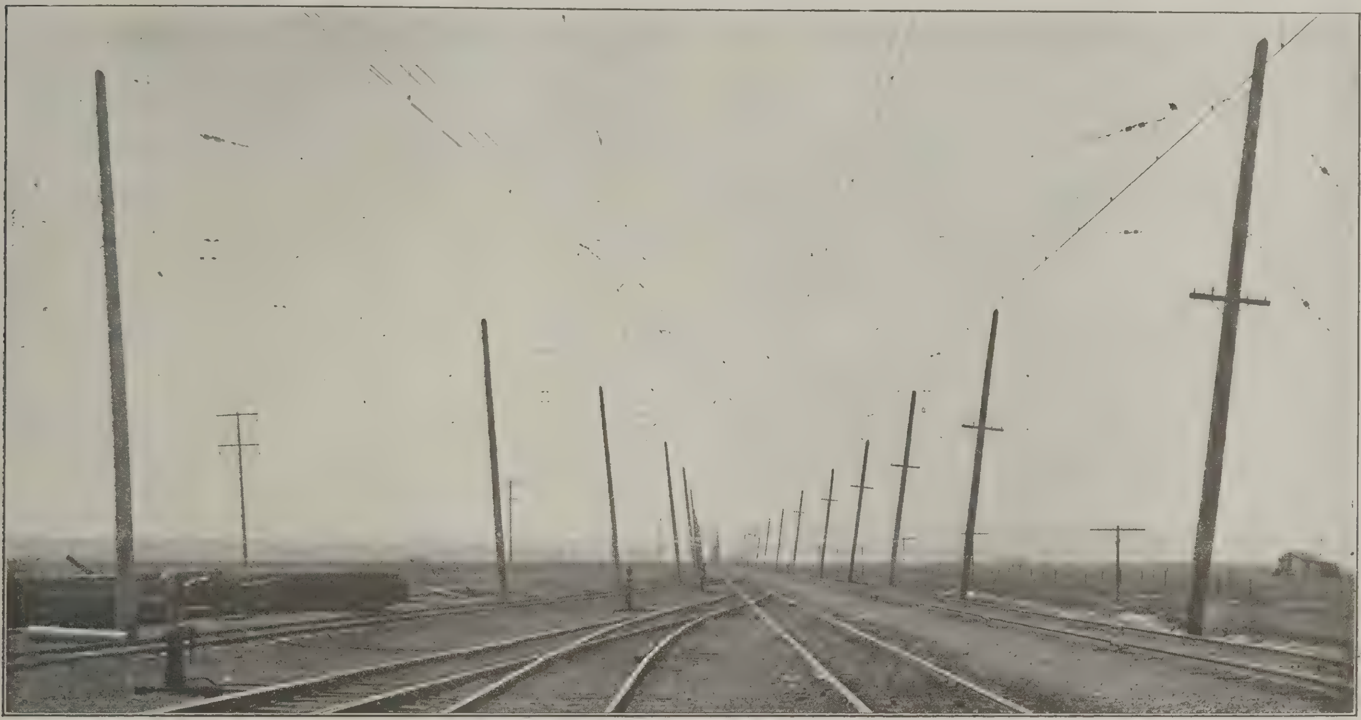


Fig. 2. Line Construction in Yards at Three Forks, Mont.

Electric Braking

A feature of especial interest in electrical operation of both passenger and freight trains on the St. Paul is the method of hauling these heavy trains when descending long mountain grades. It is a well-known fact that it requires the highest class of air brake equipment, and great skill in handling, to eliminate the danger of dropping a heavy freight or passenger train down a long sustained grade when hauled by a steam locomotive and equipped with the usual automatic air brakes. Even on a 2 per cent. down grade it frequently happens that brake shoes become red hot and wheel rims become greatly overheated, as practically all the potential energy stored in the train at the top of the mountain grade must be dissipated as heat in the brake shoes and wheels during the descent.

The St. Paul is the first to introduce electric braking with the direct current electric locomotive, and it has proved not only entirely practical under the severe conditions appearing in regular service, but the great operating benefit to be secured has also been demonstrated. When the motors are driven mechanically, as when a heavy train pushes a locomotive down grade, they act as a brake in converting this mechanical power into electricity, a part of which becomes available through the trolley system to haul other trains up grade. The same latitude in speed variation with electric locomotives is provided when braking as when operating up grade under power. The normal speed of an ascending freight train is 15 miles per hour, and for a descending train, 17 miles per hour, but if, for any reason, a lower speed becomes necessary, such as over a section of bad order track undergoing repairs, the speed can be dropped to half the above value.

The sub-stations in the St. Paul electrification are somewhat more than an average of 30 miles apart, and should there be no other trains between sub-stations to absorb the power given to the trolley by a descending train this power passes through the sub-station machinery, is converted from direct current to alternating current, and is sent into the high potential 100,000-volts distribution system connecting all sub-stations, and becomes available for use over the entire 440 miles of electrification. As a descending train will not give out as much power as it would absorb when ascending the same grade, there will always be a demand for power in excess of that given out by the descending train, and this fact taken in connection with the large industrial load connected to the same hydraulic power system makes it possible to dump into the transmission system any amount of power which the descending train may give out.

Aside from the economies resulting from electric braking, which are a possible saving of some 50 per cent of the total power demand, the elimination of brake shoe and wheel wear and the easier operation on the track, particularly when rounding curves, the greatest advantage resulting from the use of electric brakes lies in the elimination of the difficulty attending the use of air brakes in holding back long heavy trains when descending mountain grades. The electric braking of the St. Paul electric locomotive entirely relieves the air brake except for the stopping of trains or for emergency use. There is, therefore, provided a duplicate braking system, each one capable of holding a train on a down grade and there is thus offered a greater guarantee of safety in operation than would be possible with the use of the air brake alone.

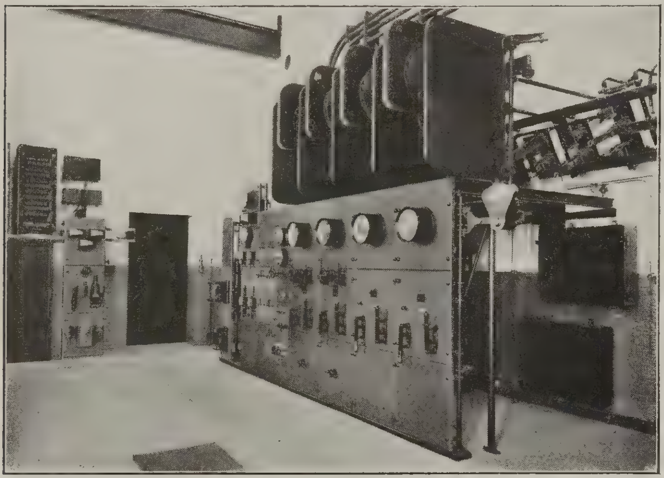


Fig. 3. Switchboard in Morel Sub-Station. Note the High Voltage Barriers Between the Circuit Breakers Above the Board.

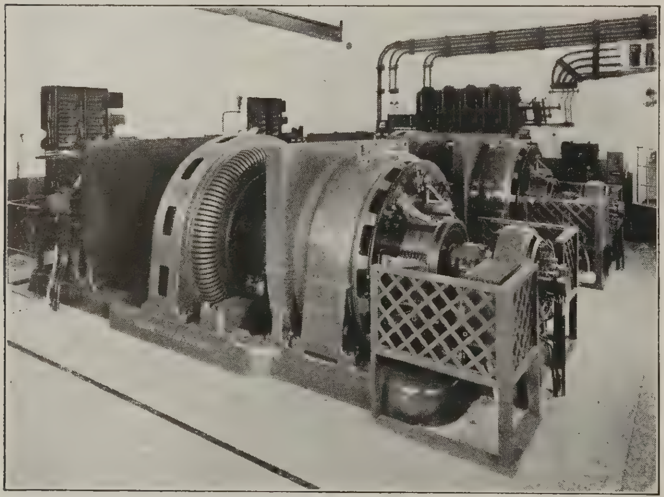


Fig. 4. The 2,000-kw. Motor Generator Sets at Morel Sub-Station.

It is an impressive and convincing demonstration to witness the operation of a 75-car train weighing 3,000 tons, between Deer Lodge and Harlowtown, a distance of 225 miles over the two mountain ranges, without the use of air brakes except when trains are required to stop. There is an entire absence of the grinding of brakes hitherto considered a necessary accompaniment of mountain railroading and all increased operating benefits are furthermore procured.

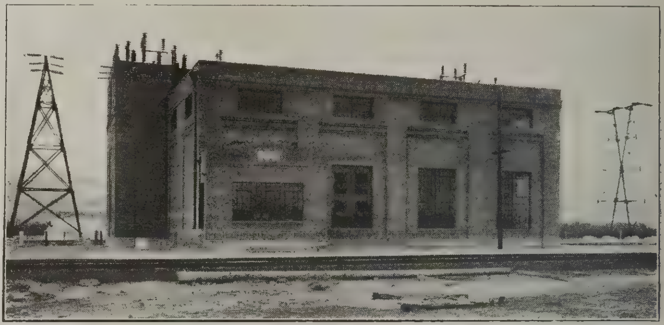


Fig. 5. Piedmont Sub-Station Showing the Railway Company's 100,000 Volt Transmission Line at Each End. The Power Company's 100,000 Volt Line Enters from the Rear.

Since electric operation has been started on the St. Paul, the heavier trains are taken down the 20 mile 2 per cent grade (the heaviest one on the division) without air brakes, more steadily and smoothly than they were on the level and the attention to brake shoes and wheels and the stopping for inspection has been done away with entirely.

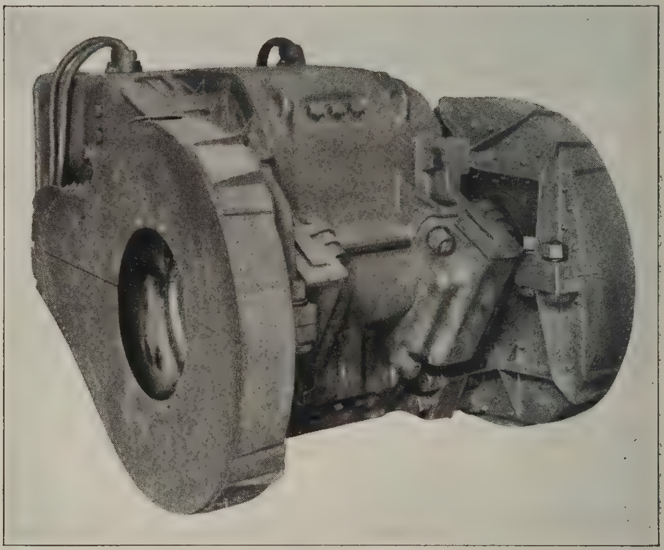


Fig. 6. One of the 430 H. P., 3,000-Volt, GE-253-A Railway Motors Which Are Used on the St. Paul Locomotives.

Electric operation over the entire section to be electrified will probably not be started until early in 1917, but it is expected to use the electric locomotives on the Missoula division this summer. At the western end of the electric zone the six sub-stations and most of the overhead construction have been completed.

It is expected that the balance of the forty-two electric locomotives will be delivered by next November.

High-Voltage D-C Railway Practice*

By Clarence Renshaw

Ten years ago, the idea that approximately 600 volts was the maximum potential to be hoped for in the operation of d-c. railways was almost as firmly established as was the belief in the days of Columbus that the earth was flat.

Then suddenly the plan was suggested of coupling the four 600-volt motors ordinarily employed on interurban cars in pairs of two in series instead of two in parallel, and of connecting the generators in the stations in a similar manner, so as to employ 1,200 instead of 600 volts. Since then the use of d-c. voltages of from 1,200 to 1,500 for the operation of interurban railways has become so common that today we are able to discuss details of high-voltage d-c. practice.

Motors

Limiting ourselves for the time being to voltages of 1,200 and 1,500 in discussing the matter, the first element to be considered of a high-voltage car or locomotive equipment is of course the motor. As far as voltage between terminals is concerned, the requirements for motors to operate two in series on such voltages differ from the well-standardized designs for low-voltage service only in the fact that slipping of the wheels to which one of the two motors in series is connected may interfere with the normal voltage distribution between them and concentrate a large part of the total voltage at the terminals of one machine. Fear of this contingency at first led to the design of motors for high-voltage service with a much larger number of commutator bars than for corresponding 600-volt service. More extended experience, however, showed that such precautions were unnecessary.

Insulation and creeping distances on motors for high-voltage service must of course be made suitable for the full potential. The extra insulation required for 1,200-volt operation is now obtained by the use of better quality rather than greater quantity of material, and the extra distances by improved shaping and arrangement of parts. Generally speaking, therefore, motors are produced today for use in series on 1,200 or 1,500 volts with the same dimensions and weights as if made for use on only 600 or 750 volts.

There have been one or two instances where motors have been wound directly for the full line potential. Speaking generally, such motors are heavier and depart more radically from standard low-voltage designs than motors for operating two in series, and moreover, they do not lend themselves as well to the operation of the cars partly on 600 and partly on 1,200 volts as is so often required. In general, therefore, they seem to offer no particular advantages and are hence but little employed.

High-voltage d-c. railway practice, therefore, in the matter of motors may be said to consist in the use of two machines in series, these being identical in construction with standard motors for low-voltage service except in the comparatively minor details of quality of insulation and length of creeping distances.

Control

In control apparatus for high-voltage d-c. railway equipments, the fundamental requirements are to provide sufficient circuit-opening capacity to overcome the greater tendency to hang which the high-voltage arcs possess, together with the necessary means to confine these arcs within proper bounds. Our first 1,200- and 1,500-volt car equipments employed 13 pneumatically operated switches, where with the same current at 600 volts eight would have been sufficient.

As with the motors, however, greater experience led to a reduction of these differences in the fundamental parts. In the types of equipment most generally employed, the additional switches necessary on account of the increased voltage have now been cut down to two for small equipments or three for large ones. In dimensions also, it has been possible to work out designs for 1,200-volt switch groups with the same cross-sectional area and the same weight per switch as those for 600 volts.

Power Supply

Direct-current power for high-voltage lines was first obtained by the use of two 600-volt generators, either engine or motor-driven, connected in series. Since there was no particular object in retaining two generators in series such as there was for retaining two motors in series on the cars, generators for delivering 1,200 or 1,500 volts directly were soon produced. At first these were of the ordinary commutating pole type. Such machines now, however, usually employ a compensating winding as well as commutating poles.

The next step in the production of high-voltage d-c. power was the use of two 600-volt, 25-cycle synchronous converters connected in series, and while this was considered a radical step at the time it was first proposed, the performance obtained was so satisfactory that single 25-cycle converters producing 1,200 or 1,500 volts on one commutator have now been developed and are in successful use. With 60 cycles, the maximum voltage so far employed from a single machine is 750 so that two machines in series are still required for high voltage lines. The performance on this basis, however, is most excellent.

Common substation practice for high voltage d-c. lines is now to employ single synchronous converters where power at 25-cycles is available, and to use either motor-generator sets or two converters in series, where 60-cycle power is employed. A particularly efficient substation arrangement on the latter basis is secured by installing three synchronous converters so arranged that any two of them may be connected in series. This gives a spare machine at a minimum expense. If a single bank of three transformers is used for supplying these converters, a spare transformer as well as a spare converter is also secured so that the station is prepared for almost any emergency.

Switching

In the matter of switching, the principal changes which have been made in handling current at 1,200 or 1,500 volts instead of at 600 volts have been for the purpose of insuring safety to the operators rather than for any other reasons. For this purpose, switchboard panels have been made higher than for 600-volt service and the circuit breakers located on them so as to be out of direct reach. For opening and closing the breakers, long wooden rods leading to insulated handles on the lower part of the panel, are provided. Where two or more breakers are located side by side, large barriers are placed between them to prevent any tendency to flash across. Knife switches have also been located out of reach in a manner similar to the circuit breakers and arranged with rods for distant control.

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*Abstract of a paper presented at the 320th meeting of the American Institute of Electrical Engineers, New York, April 14, 1916.

Economic Significance

In studying the development of 1,200 and 1,500-volt practice, the fundamental point which appeals to me is the ease, success and speed with which so radical a departure from previous practice has been carried out. In most developments of so far-reaching a nature, many sources of difficulty are usually overlooked at first and must be cared for in later apparatus at increased expense. In the high-voltage d-c. railway system, however, just the opposite has apparently happened. Many of the possible difficulties seem to have been over-estimated in importance and much of the trouble anticipated has failed to appear. It has therefore been possible to gradually simplify and cheapen the various fundamental parts which go to make up the system instead of having to follow the opposite and more usual procedure.

Ultimate Limits of D-C. Voltage

The general limits upon which standard practice in any industry ordinarily settles are usually fixed by broad economic considerations rather than by physical limitations. It is entirely possible for instance to operate trains at maximum speeds of 90 miles per hour or more, yet the maximum ordinarily attained is from 60 to 80 miles per hour. Physically speaking, also, interurban cars can be run at speeds similar to these, yet the general average on such roads is from 50 to 60 miles per hour. These values have been established by gradual increases from lower ones until without any conscious effort, standardization has been automatically secured.

In the voltages which may be employed with the 4-c. railway system, there is some tendency toward this same procedure. If no efforts were made to the contrary, it is not improbable that starting from the voltage of 3,000, which we have today on the Chicago, Milwaukee & St. Paul, we would next hear of the employment of 3,600 volts, then possibly 4,200 volts and so on up in corresponding steps. Sooner or later, however, a point would be reached where, by common consent, these increases would stop just as this has happened in the matter of speeds.

While in a way, such a procedure would be the conservative and natural way for progress to come about in the use of higher d-c. voltages, its disadvantages are too obvious to require mention. The apparently more radical plan of trying to select in advance the voltage at which such increases would naturally stop and of going at once to this voltage would hence seem to be the more rational and really the more conservative as far as the general good of the industry is concerned. It has been with this idea in view that our efforts toward the use of direct current at 5,000 volts are being put forth. With practical apparatus for this voltage available, the problems of distributing and collecting the necessary power for the largest locomotives likely to be required can be readily solved so that although further increases might be possible they should be entirely unnecessary.

Operation of 5,000-Volt Equipment*

The general construction of the 5-000-volt experimental equipment on the Grass Lake line of the Michigan United Traction Co. and the results of its first few months' operation have been so widely covered by the technical press that it is unnecessary to refer further to them except to say that the equipment is still in operation on the same successful basis, and that at the time this is written, it has run a little over 30,000 miles. During the five months from October 1 to March 1, the car averaged 5,295 miles per month on a schedule which allows only 15 miles per hour, and its record would have been even greater than this had it not been for numerous mechanical difficulties with the trucks, wheels, brake rigging, stove, pilots and other mechanical parts of the car for which the equipment was in no way responsible. During the four months of November, December, January and February, which, on account of weather conditions, are ordinarily considered the worst in the year, the car ran 23,320 miles or an average of 5,830 per month.

During this period the car operated through severe snow, sleet and rain storms and for a short period even ran with two of the commutator covers missing, these having been lost on the road. The motors and control were purposely allowed to go with a minimum of cleaning and other care, and various reports sent in by the men in charge refer to the presence of wheel wash, dirt and other obnoxious substances in the motors and switch groups, although no damage was caused by them.

While as yet only the one equipment now in experimental operation has been built, various designs of other sizes have been considered and with the special double armature type of motor and double jaw type of switch which have made this equipment possible, unusual flexibility in meeting a wide range of conditions can apparently be obtained.

In most of the considerations of the use of d-c. voltages of 2,400 and 3,000, there has always been a certain minimum size of motor which could be economically produced and this size has been undesirably large for certain classes of service. With the special double armature type of motor for 5,000-volt equipments, however, the experimental equipment already in use is about as small as would ordinarily be required, although even this is apparently not the minimum limit. On the other hand, the design seems equally adaptable to large sizes.

Conclusion

Broadly viewing the high-voltage d-c. practice which we find today, and its significance to the industry, there are four ideas which appeal particularly to me. The pernicious flexibility of the 1,200 and 1,500-volt systems and the innumerable alternatives which they present for application to any definite case in interurban work seem to give timely warning of the great desirability of early

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*This installation was completely described in the November, 1915, issue of the *Railway Electrical Engineer.*

standardization in the matter of higher d-c. voltages. The comparative ease with which apparatus for these voltages has been developed gives a most encouraging feeling for further development along the same lines. The possibilities which a d-c. system at 5,000 volts would offer were the apparatus commercially available make this voltage seem a logical one, and the results obtained with the experimental equipment now in operation give great hope that this voltage may some day be established commercially as a standard of high-voltage d-c. railway practice.

Discussion

Owing to the unavoidable absence of the author, the paper was read by N. W. Storer, general engineer, Westinghouse Electric & Mfg. Company. Mr. Storer also presented lantern slides illustrating the 5,000-volt equipment which had been described.

William J. Davis, Jr., general manager of electrification of the Southern Pacific, stated as regards the tendency to higher voltages, that it would appear that the proper voltage would depend on certain limitations as to the maximum tonnage to be hauled and limitations as to speed. The tonnage of a system is dependent upon the number of tracks that are in service and in a single track road, in order to handle heavy tonnage, it is necessary to adopt higher voltages than would be required for a road having sufficient traffic to require two, or three, or possibly four tracks. In the case of a four-track road, all the tracks being in multiple, the drop in voltage in the track is greatly reduced. The advantage of having the proper conductor or the third rail for all four tracks in multiple is also obtained, and even when very large powers are required, say 3,000, 4,000 or 5,000 horse-power on a four-track road, it will be found, insofar as the distribution system is concerned, that modern voltage, say 1,200 or 1,500, would give as good results as could be obtained at 3,000 volts or more, in the case of a single track or double track road.

Mr. Davis also pointed out that with a single track freight road it will be found that upon the basis of the weight of trains now in use, very little improvement in power factor is procured if the sub-stations are placed more than 30 or 35 miles apart. He said the whole problem narrows down to the question as to the number of locomotives required on a given division and their cost. As a general rule the locomotives or rolling stock of a single track road will cost about one-third of the total cost of the electrification. If, therefore, there is a material increase in the cost of a 5,000-volt locomotive as compared with one of 3,000 volts, this increase in cost may prove the determining factor. In the case of a double-track road in which the locomotives would be greatly increased in number, this difference would be still more sharp and would point to a limitation of voltage possibly less than 5,000 volts as applying to most of the heavy freight traffic now obtaining.

William E. Potter, chief engineer, railway and traction department, General Electric Company, thought the text of the ultimatum (meaning voltage) was very well covered in Mr. Renshaw's statement that "the general limits upon which standard practice in any industry are ordinarily settled are usually fixed by broad, economic consideration rather than by physical limitation." Mr. Potter went on to say that there are several problems that enter into the determination of any economic result. He pointed out that in any electrification, there are certain features which may be considered generally as part of the general scheme. Under direct current operation the initial cost of maintenance and depreciation on some of these features are but little affected by the operating voltage but other features are so material that they have to be a determining influence in the selection of the voltage most favorable to economic results in the ultimate recognition of general standards. The power-house transmission lines and track bonding are, he claimed, so little affected by the choice of voltage that these features are not a factor in the economic determination of the particular voltage to be used. The sub-station equipment used in all the established types of apparatus have generally a somewhat higher cost at the higher voltage for a given kilowatt. However, at the higher voltage the stations would be placed further apart and some gain is made in that direction, although not in a direct ratio with a higher voltage. As the amount of included traffic between the sub-stations becomes greater, the individual station has to be of larger capacity.

Mr. Porter also pointed out that the two features which are materially influenced by the voltage are the cost of the feeder copper and the rolling stock. In the determination of the voltage for the Chicago, Milwaukee & St. Paul, very careful study was made of 3,000 and 5,000 volts. There was practically no difference in the initial cost as a whole, but there was a difference in the division of the cost. If the copper was less and the rolling stock was more, the sub-stations would be slightly decreased in the total cost.

It may be of interest to give the percentage cost values that applied to the different elements entering into the St. Paul electrification as given by Mr. Potter. The high tension transmission line, which extends the entire length of the electrification, was about 10 per cent of the total cost; the overhead construction, the feeder, copper and the trolley, 28 per cent; the bonding of the track about 4 per cent; the sub-stations about 18 per cent, and the locomotives, 20 per cent. The overhead construction and the feeder copper, together with the sub-stations, represent 46 per cent and leaving out the overhead work, which would be essential at any particular voltage, the cost of copper is something less than 40 per cent and the cost of the locomotives also about 40 per cent. Considering the depreciation and maintenance it is better that an equivalent expenditure should be in copper rather than in locomotives and rolling stock, which require maintenance and up-keep. He felt that to economize in copper and to spend that same money for rolling stock is working on the wrong side of the balance sheet.

Another important point brought out in Mr. Potter's discussion was that he judged from experience to date that the trolley on the Milwaukee lines will last anywhere between 20 and 50 years and that it is good for a number of million passages. He said, "The problem of collecting current, so far as 3,000 volts being a limitation is concerned, seems to be effectually disposed of."

Calvert Townley, assistant to the president, Westinghouse Electric & Manufacturing Company, stated that it would be better to put a little more in copper, which was staple and had a lower depreciation, than to put it into the equipment, which had a higher rate of depreciation. We should bear in mind, however, that an increase in the voltage which can be used for transmission is a fundamental and a permanent advance and the resulting saving in copper will always be there.

Benjamin F. Wood, vice-president and chief engineer of the United Gas & Electric Engineering Corporation, of New York, thought that the electrical engineer is getting himself into some difficulty with the railroad people when he talks about costs and the little refinement in connection with the efficiency of the operation. He showed that when the total fuel cost on a trunk line is only 5 or 6 per cent of the operating expense and it is necessary to sell electric power to a steam railroad at approximately the cost of fuel, when operation of electric service is started, it is evident that a saving of 5 or 10 per cent of this fuel percentage is of trifling importance when compared with the dependability of operation. The railroad man wants something he can be sure is going to operate continuously and reliably and that is the thing to which all efforts toward standardization should be directed.

Albert Horace Armstrong, assistant engineer, railway and traction department, General Electric Company, called attention to a statement made by the author, who when referring to 2,400 volts, said that "from a general standpoint, however, while the results have been welcome as a contribution to the development of the art, suitable applications for this particular voltage are apparently somewhat lacking" and also that "for heavy traction on the other hand this voltage is much too low to solve the problem in a sufficiently comprehensive way to attract the investment of capital in electrification. Even 3,000 volts, while overcoming the latter disadvantage to some extent, does not do so completely." Mr. Armstrong felt that those statements rather discredited all the installations now operating at more than 1,500 volts and that it fell flat as an argument considering that one electrification at 3,000 volts is equal in mileage to all the electrifications thus far attempted in the United States.

Referring to the St. Paul electrification, Mr. Armstrong pointed out that in the 440 miles there are 14 sub-stations; that these sub-stations aggregate 59,500 rated full load capacity; that the average load on the entire system would probably not greatly exceed 16,000 or 17,000 kilowatts, and that the low factor, then, would be less than 30 per cent on the installed capacity, and everyone of the sub-stations has a reserve machine that is not called into service in the normal operation of the road. He also showed that with a higher voltage the sub-stations can be either spaced further apart and the amount of copper which would be used with the lower voltage retained, or less copper can be put in the road and all sub-stations placed near together, or it is possible to compromise and get some of the benefits in each direction.

He showed that on the St. Paul the average feeder copper throughout the whole 440 miles, except on two of the sharper grades, is only 500,000 circular mills and that this copper will give an average drop of less than 10 per cent with the normal operation. He remarked that the drop may reach 20 per cent but, with the average tonnage going over the road, he said he would be greatly surprised if the average drop at the end of the year is over 10 per cent. He pointed out that instead of reducing the capacity of sub-stations it is possible to increase their aggregate capacity with a greater spacing, especially in view of the greater cost of the sub-stations, due to the higher voltage of the apparatus installed, and that it is quite possible the total cost of installation will be greater due to the increase in capacity demanded.

In summing up, Mr. Armstrong said that, relying mostly on Mr. Potter's arguments advancing the 3,000 volts, he could not accept the statement of Mr. Renshaw's that 5,000 volts is the approximately proper voltage to standardize for the steam railway electrification, especially in view of the fact that only one motive power equipment is now operating at this voltage. He added that while the advance to the higher standards has been apparently, to the world at large, a simple matter, he could see that the success attending its use had, in fact, been brought about by the many years of work of some eminent and capable engineers. Mr. Armstrong also pointed out that the paper, itself, did not throw any light on the economic advantage of adopting 5,000 volts nor does it go into the results sufficiently to lead to any conclusion that 5,000 volts is preferable to 6,000 or 7,500 or 10,000.

In closing the discussion **N. W. Storer** said he agreed perfectly with Mr. Potter in regard to the economy of the installation and that he had always claimed that it was simply a matter of dollars and cents which is going to ultimately decide the system of electrification that can be used, with the understanding that such a system must give good reliable service in every case and must operate with a reasonable degree of maintenance cost. He did not think that a system which had an enormous cost of maintenance could operate with the greatest reliability. Referring to Mr. Renshaw's purpose in writing the paper, Mr. Storer said that he did not believe that Mr. Renshaw had any intention, whatever, of starting out to show that 5,000 volts is a standard voltage which can at once be applied to everything, but simply wished to make it a point to aim at and he said it certainly seemed more logical than to proceed by the small steps which have been made. He pointed out that manufacturers are now required to design apparatus to meet many different systems, really to perform the same work, and in this way the cost of development and manufacture runs up to an enormous figure which must be borne by the operating companies, else it could not be done. He said, "I simply feel, and I know that it was Mr. Renshaw's thought, that we should aim at something which is high enough to do the work."

A Modern Yard Charging Installation

By C. R. Happ*

The Buffalo, Rochester & Pittsburgh Railway Company recently installed a new coach charging system in its yards at East Salamanca, N. Y., the division point between the Buffalo and middle divisions. As the Rochester division through trains lay over at this point, it makes a very convenient location for charging their coach lighting batteries.

A view of the passenger station at East Salamanca is shown in Fig. 1. This installation shows the neat appearance and substantial character of the charging outlet, and it will be noted that the artistic design of the foundations harmonizes with the lamp-post and other surroundings.

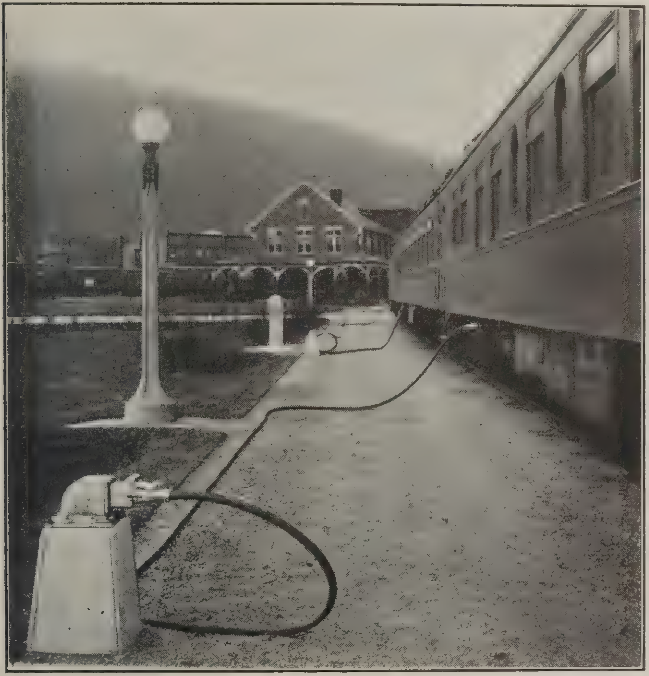

Fig. 1. View of the Passenger Station of the Buffalo, Rocheste: & Pittsburgh at East Salamanca, N. Y. Showing the Neat Appearance of the Charging Outlets.

There are two yard charging circuits with two outlets on a circuit, each circuit is controlled with a 60-ampere double pole fusible switch and the voltage on each circuit is controlled by a rheostat as shown in Fig. 2. The ammeter is connected so that it reads the total current taken by all charging outlets.

The outlets, four in number, are spaced 82 ft. apart, as shown in Fig. 1 and are the Crouse-Hinds Company's type UGEL galvanized Condulets, furnished with base plates, mounted on special concrete foundations made by the railway company's forces.

The design of these foundations, Fig. 5, shows one 2-in. galvanized conduit and two 1¼-in. galvanized conduits, lettered "A," "B" and "C," entering from three respective sides of the foundation. If a foundation is wanted for a straight run it is made with conduits "B" and "C," or if wanted at the end of a run and the supplying line is to be laid at right angles to the run, it is made with conduits "A" and "B" or "A" and "C," as the case may be, thus making one design answer all purposes.

The foundations, which are 12 in. square at the top, 20 in. square at the bottom and 3½ ft. in height, are placed 2 ft. in the ground, leaving the Condulet opening 1¾ ft. above the ground for snow clearance. They have a recess 4 in. deep by 6¾ in. by 6⅞ in. moulded in the top for use as a junction box. All wire connections and splices were made in these recesses, which are water tight after the condulets are applied.

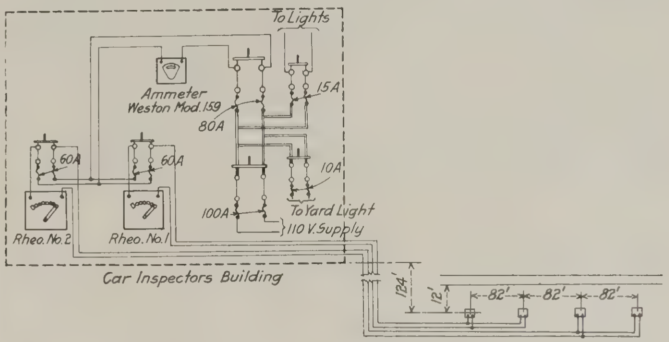

Fig. 2. Wiring Diagram of the Switchboard and the Yard Circuits.

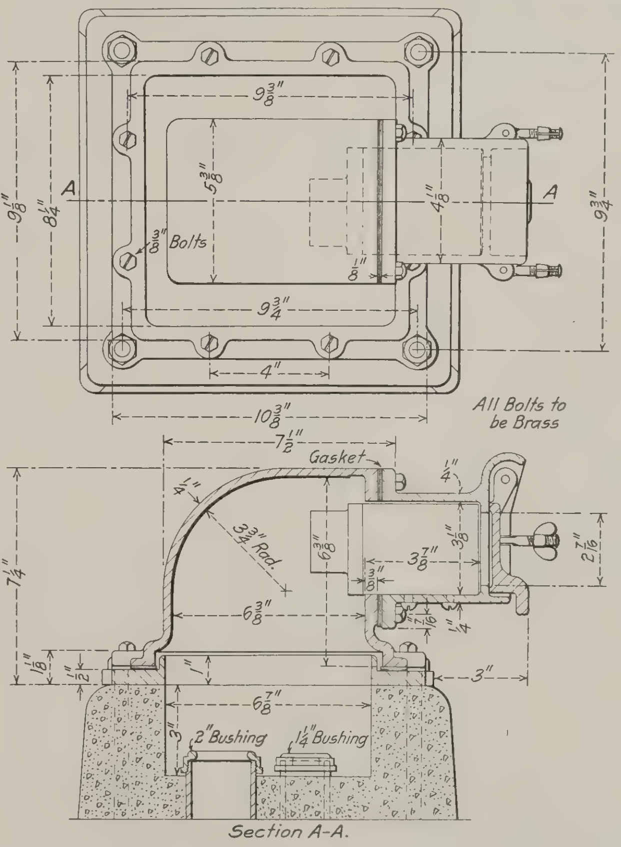

Fig. 3. Details of Crouse-Hinds Company's Type UGEL Galvanized Condulet, Showing Method of Mounting on the Top of the Concrete Foundation Shown in Fig. 3.

No. 6 B&S gage duplex stranded lead encased cable was used, run in conduit placed 1 ft. below the surface of the ground and imbedded in clay to a diameter of 12 in. to protect it from the corroding effect of cinders, coal wash, etc.

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*Signal Inspector, Buffalo, Rochester & Pittsburgh Railway Co.

For the portable leads No. 6 B&S gage duplex deck cable was used, protected by 1 in. garden hose, using the Crouse-Hinds Company's BPFA100 galvanized plugs for the receptacle on the foundations and their BPA100 plug for the coach receptacle. Leads constructed in this way are waterproof and durable.

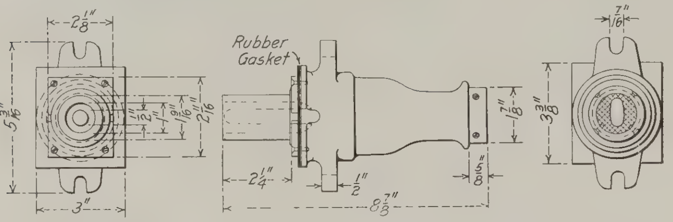

Fig. 4. Detail of the Crouse-Hinds Company 100-Ampere, 125-Volts Charging Plug, Catalogue No. BPFA-100 for the Receptacle on the Foundation. The BPA-100 Plug Is Used for the Coach Receptacle.

The controlling apparatus consists of one ammeter, two rheostats, four double pole single-throw knife switches and necessary fuses placed in the car inspector's building, a distance of 124 ft. from the first outlet, while the 110-volt direct current supply, protected by 60 ampere fuses is obtained from the railway company's power house, located a short distance away.

The installation was made by company forces under the direction of the signal engineer. It makes a neat and convenient arrangement in keeping with the immediate surroundings, and is characteristic of the high standard of the engineering work of the Buffalo, Rochester & Pittsburg.

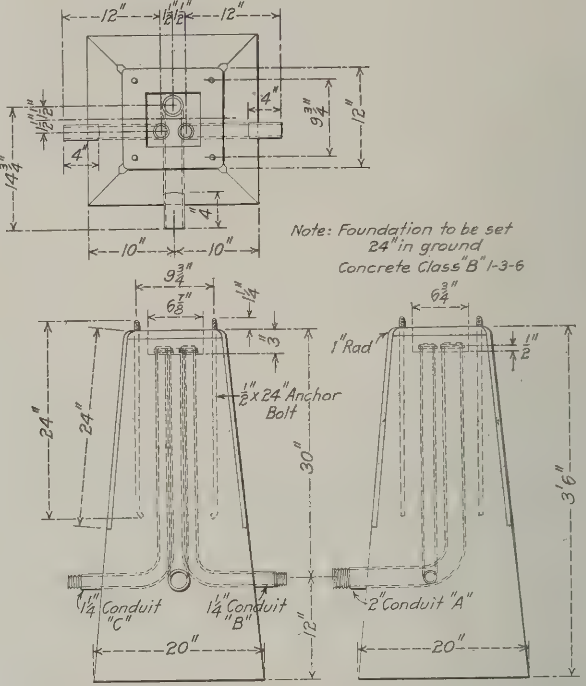

Fig. 5. Details of the Concrete Foundation for the Charging Receptacles.

Commutators and Commutation*

By Gordon Fox

II

A commutator must be round and exactly centered. A bent shaft or looseness in the bearings may permit the commutator to run out of true. The larger units generally have their commutators turned with the armature mounted on a temporary test shaft. When the permanent engine shaft is later inserted a slight eccentricity is likely to result. Commutators may become oval or eccentric through excessive heating or may set untrue as they season out. In manufacture they are baked in an oven and later run for a short period. In use they are subjected to both heating and running simultaneously with the result that while new they may take up at any yielding points. Such commutators may require truing up once or twice before they reach their final condition. Commutators may be baked to expedite their setting or after repairs are made requiring removal of a segment or more. If heated up sufficiently the shellac binder in the mica-bond softens and flows slightly, making a solid mechanical unit. The necessary heat would injure the insulation if armature and commutator were both inserted in an oven. Large commutators may be easily heated in the assembled machine. This is done by shifting the brushes considerably off neutral, short-circuiting the armature across an ammeter and exciting the fields only enough to generate approximate full-load current through the armature circuit. Some sparking may occur at the brushes which, taken together with the heavy short circuit currents in the brushes off neutral, will suffice to heat the commutator thoroughly. When the commutator is properly heated it should be tightened. When it has cooled the bolts should again be turned to take up the cooling contraction. A commutator thus treated and then turned is quite certain to retain its set.

Turning Commutators

All commutators wear or roughen sufficiently in time so that they require truing. Small armatures can be handled better in a lathe after removal from the machine. The commutators of large generators or motors can be quite easily turned in place without dismantling the machine. Some rig must first be devised to take up the play in the armature shaft. Then the armature is turned over at low speed by throttling the engine or by driving from a belted motor. Large motors can be trued while revolving under their own power, low voltage being impressed on the armature through a rheostat. This practice is not advisable where other means are possible. The best surface speed for turning is about 500 ft. per minute. After turning, the commutator should be filed sparingly with a large mill file to remove the tool marks, care being taken not to untrue the surface. Final smoothing may be done with sandpaper on a block. A fine sandstone is preferable, as it abrades the entire surface uniformly, whereas sandpaper gives slightly and rides over the mica. Emery cloth should never be used, as carbon particles enter the mica and weaken its insulating strength.

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*Part I appeared in the April issue.

There are many designs of truing devices upon the market. They comprise essentially some form of tool support fitted with hand wheel and screw for feeding the tool. They are usually bolted either to the brushholder ring or the bearing pedestal, the former type being usually more rigid. A commutator trued at low speed may sometimes be out when revolving at high speed. For such cases a sandstone block may be substituted for the tool and fed across the commutator under pressure while the machine is "up to speed." Equipments are to be had for grinding commutators with a wheel which is moved along much the same way as a turning tool.

When truing the commutator of a large machine having open risers it is well to place a cardboard shield in front of the risers and windings to prevent turnings from lodging internally. If the work is done in the machine the brushes should be raised before truing and they should be freed from copper dust before lowering. After truing the commutator a careful inspection of the mica segments is necessary to detect and remove particles of copper dragged across from one bar to the next. It is well to administer a coat of insulating varnish on the end of the commutator next to the bearing as a preventative against oil troubles. Undercutting is performed after the armature is trued. No matter how carefully a commutator is finished it is comparatively raw until it is worked into condition. It is best to run the machine without load for a time, giving the brushes a little extra pressure perhaps, in order that the surface may take on a little polish or glaze before being subjected to the ravages of load conditions. After the machine has been in service a few hours it is well to lift the brushes and scrape off any particles of copper they have accumulated. Copper particles in the brushes are very likely to start trouble and are commonly found after newly dressing the commutator surface.

Action of Oil

Occasionally a commutator gives trouble through "pitting" or eating away of the mica segments. This trouble has been traced to the action of oil. Oil tends to dissolve out the binding material bonding the mica particles together. Small particles of carbon and copper then become embedded in the mica segments. These lower the resistance between segments, causing leakage and ring fire. The leakage occurs during the period that the voltage between bars is comparatively high while the coil is in a strong field. Ring fire often causes local burning of the mica and pitting results. The remedies for mica pitting are: sparing use of oil in operation, use of mica segments having insoluble binder for repairs and cleaning out local faults as soon as detected by thoroughly scraping out the damaged part of the segment and filling the space with a paste composed of plaster of paris, mica powder and shellac baked into place.

Brushes and Brush Troubles

The primary function of brushes is to collect or deliver current. Incidentally they are required to short circuit portions of the commutator, bridging two or more segments. They must limit the currents flowing as a result of this short-circuited condition. Also they must properly abrade the commutator and furnish lubrication. In some machines one function is more important, in another a second requirement prevails, so that various grades of brushes are best suited to differing purposes.

Brush Material

The base material almost universally used for brushes is carbon. The reason is to be found in the comparatively high contact resistance between carbon and copper. The resistance of an armature coil, particularly in the large capacity machine, is necessarily very low. Due to conditions already mentioned, a coil is likely to have generated within it a pressure of two or three volts at the instant it is short-circuited by the brush. If this brush were of copper, for instance, the resistance of the local circuit would be so low that a short circuit current would flow which might be greater than the work current of the machine, and commutation would be correspondingly poor. If carbon brushes are used the resistance of the circuit from bar to brush and back to adjoining bar will be greatly increased, perhaps twenty times. The short circuit current will be correspondingly lowered and commutation improved. There are two peculiarities about carbon brushes. First, the contact drop is relatively much greater than the internal resistance brush drop. Second, the contact drop does not vary directly with the current. It does depend somewhat upon the kind of brush, the condition of the commutator surface, the brush pressure and like mechanical factors. The contact drop between brush and commutator is usually about 1 to 1.25 volts. Doubling the current may increase this value to 1.4 volts or thereabouts. Beyond this it will increase comparatively little. Conversely, 2.8 volts (twice 1.4) will send through the local brush circuit twice the short circuit current that 2.5 volts will cause. Consequently, if local currents are to be limited to low values the voltages in the short-circuited coils must be maintained within the limits of normal brush contact drop. In practice it is found that the voltage across the short-circuited brush zone should not exceed 2 to 2.5 volts. The safe voltage can be controlled somewhat by varying the qualities of the brushes, since some brushes have higher resistances than do others. The fact that the work current also traverses the brushes and contacts limits the advisable drop. In general, high resistance brushes decrease short circuit currents and tend to improve commutation, although increasing the losses and possibly cause overheating. They are, of course, not helpful where the cause of sparking is not primarily electrical.

Width of Brushes

The allowable width of brushes is determined by the width of the commutating field. If there is a broad neutral zone in which the voltage between segments is low, then the width of the brushes may be greater than in a machine having a narrow neutral zone with areas of considerable voltage immediately adjacent. Not infrequently machines are equipped with brushes which are a little too wide. They then span too great a commutating zone and the shirt circuit currents become excessive, sparking resulting. This sparking will usually result in a burning action. The actual work current per brush is generally so low that it will not cause burning. Consequently, burning may often be taken as an indication of excessive short circuit currents. Such brushes show a dull black area under one edge of the brush, which obviously is burned while the remainder of the brush face is polished. If the short circuit currents cannot be reduced by shifting the brushes, adjusting the interpole or other means, it is sometimes helpful to bevel off the edge of the brush as far as the burned area extends.

Current Density in Brushes

Since the work current of a machine travels through the brushes sufficient area must be provided to conduct the load without undue loss or heating. In practice a current density of 40 amperes per square inch of area has been found a conservative value. In reality there are two currents to be considered, the load current and the short circuit currents. The latter may equal or exceed the former. Consequently interpole machines and other designs providing good commutating conditions can be equipped with brushes working at higher densities than machines involving comparatively large short circuit currents.

Brushes in Parallel

It is difficult to secure equal division of current between brushes and brush arms working in parallel. This may be due initially to a number of causes. Electrical conditions, air gap variations and unequal brush pressures are typical causes. When a difference once occurs it tends to accentuate itself because carbon has a negative co-efficient of resistance. If one brush takes more than its share of current for a short period that brush heats, lowers its resistance and tends to assume more current. The brush may become so hot that it glows. The surface then burns slightly and the contact resistance increases so that the load through the brush drops off. Where there are many brushes in parallel involving a large total current it is evident that one brush may easily assume an excessive current without materially decreasing the amounts carried by the other brushes. Where there are but few brushes in parallel the division is likely to be more uniform.

Brush Spacing

The symmetrical spacing of brushes is important. Upon machines that have wide neutral zones a little variation in spacing is less harmful than upon more sensitive designs. Also, a slight shift off neutral position will cause more serious results if the brushes are unequally spaced, since such a shift emphasizes the voltage unbalancing. Correct spacing can be most easily secured by the following method. Cut a strip of tough paper about an inch wide and of length a little greater than the circumference of the commutator. Place it around the commutator under the brushes, allowing the ends to overlap. Cut both layers simultaneously along a mica segment. This makes the strip exactly equal to the circumference of the commutator. Removing the strip, divide it off into as many sections as there are brush studs. Reinsert the strip under the brushes and set the edges of the brushes to toe the marks on the strip. This method is more accurate than counting segments between studs and attempting to thus equalize the distances. It is also easier.

Brush Position

The brushes, after being properly spaced, must be shifted to position. The procedure is slightly different, depending whether or not an interpole is present. With shunt and compound wound machines of the simpler type the neutral shifts. The shifting is with the rotation in the case of a generator, against the rotation in the case of a motor. Generator brushes should be set as far with the rotation as will afford black commutation at no load. Motor brushes are set as far against the rotation as will permit black commutation at no load. Shifting the brushes of a motor against the rotation increases the motor speed, consequently some adjustment can be obtained in this way. Commutation should be considered first, always.

Interpole machines, if properly designed and adjusted, retain a fixed neutral under all ordinary loads. The best way to locate the brushes of an interpole motor is to run the machine first in one direction, then in the other, changing the brush position until the speed is the same for both directions. If the motor be of the adjustable speed type, this adjustment should first be made with full field to secure approximate position, then checked with weak field to secure greater accuracy. If the interpoles are of proper strength they will retain the neutral fixed under load, if too weak the neutral will shift as in a shunt machine. If too strong the shift will be of opposite effect. The interpoles of a motor may be adjusted by running the motor first at no load and then at full load with brushes at reversible point. If the motor slows down with increase of load, the interpole is none too strong, perhaps insufficient. If the motor speeds up and races under load the interpoles are too strong and must be shunted with German silver or other resistance wire. Correct interpole strength provides nearly the same speed at full load as at no load.

Correct Interpole Strength

To determine the correct interpole strength for a generator is slightly different. Here the neutral zone can be located by means of a low reading voltmeter to which are attached a pair of leads with their tips arranged to span two adjacent segments of the commutator. At the neutral point the voltmeter reads zero, on one side of the neutral it has a positive reading, on the other side a negative reading. The brushes can be set at no load over the neutral thus found. If this neutral remains fixed when load is applied the interpoles are correct. If the shift is with the rotation the interpoles are not overstrong. If the shift is against the rotation a shunt must be provided to lessen the effect.

Picking Up Copper

Experience has shown that current passing from brush to commutator and vice versa exercises an action sometimes termed "electrolytic," although not truly so. It is more nearly the action of an arc. Minute particles are burned away from one contact surface and deposited upon the other surface. The particles are carried in the same direction that the current flows. This action may have very detrimental effects upon commutation. Particles of copper may burn away from the commutator and be deposited upon the brushes, usually accumulating in spots. The contact resistance of these spots is lowered, allowing greater short circuit currents to flow. Also, the resistance being lowered at the particles, the affected brushes assume an undue share of the load, leading to glowing and burning. "Picking up copper," as this action is commonly termed, is not necessarily confined to the brushes of one polarity, since the short circuit currents both enter and leave each brush. The trouble is more likely to occur under the brushes receiving the load current. The positive brushes of a generator and the negative brushes of a motor usually show the greater tendency to pick up copper. In staggering brushes to secure equal wear, if alternate studs be similarly located all the brushes of each polarity will be in the same line. The commutator is then likely to wear in ridges. If the brush arms be staggered in pairs this condition will be corrected.

Picking up copper leads to high mica. The copper is burned away, but the mica is not so affected. The mica must be abraded at the same rate that the copper is burned if good contact is to be maintained. High mica is often attributed to unequal wear of copper and mica. This viewpoint is strengthened by the fact that with thick mica the action is most serious. Also, in commutators having many bars, hence relatively more mica, the trouble is prevalent. In both these cases it is the higher percentage of mica which causes its slower wear, allowing the copper to be burned away more rapidly than the mica is worn. It is physically impossible to wear the copper away below the mica. High mica may sometimes be remedied by eliminating the conditions causing burning and eating away of the copper. The use of more abrasive brushes may eliminate trouble by keeping the mica worn down. Undercutting, already mentioned, is the most frequently applied remedy. This procedure may require or make desirable the use of a different brush than is used upon a smooth commutator. Except where the brushes cover several bars, slotted commutators are likely to produce chattering of the brushes unless frequently lubricated. Therefore, with undercut commutators self-lubricating brushes are recommended. These brushes are composed largely of graphite and are of lower resistance than ordinary brushes. The lower contact resistance may tend to increase short circuit currents.

Angular Position of Brushes

The angular position of brushes is important, as it affects their contact. Brushes for reversible motors should be radial, others should make an angle of about fifteen degrees, with the outer end of the brush in advance of the face. The brushes should be in front of the stud. This arrangement causes the brushes to be forced down onto the commutator rather than lifted away.

Brush Fit in Holders

Brushes should fit snugly in box type holders in order that they may not rock and chatter. They should be free enough, however, to slide easily under the spring tension applied. The copper plating of brushes should be scraped off the end next the commutator for a distance of about one-quarter inch, otherwise the current will be localized at the edges and carried by the plating.

Brush Fit on Commutator

The face of the brushes should fit the curvature of the commutator very accurately. They should be sanded in place by drawing strips of fine sandpaper under them, holding the paper close to the commutator to insure the proper shaping. If the brushes are in box type holders, where they have a chance to rock they should be sanded by drawing the paper in one direction only, the direction of rotation, by lifting the brushes, returning the paper and repeating. This assures a fit under actual running conditions.

Brush Tension

Brush tension is a factor quite generally neglected, although in reality important. The most efficient pressure is the lowest consistent with a low contact loss and freedom from sparking, pitting and glowing. The proper pressure varies according to the class of service. Ordinary motors and generators require 1.5 to 2 pounds per square inch cross section. Crane, railway and haulage motors should be adjusted for higher pressures, 4 to 7 pounds per square inch being good values. Uniformity in tension is important, since it affects the current distribution. Particularly for large, heavy current machines this is true, since in machines of that type a brush having better contact than its fellows will become quickly overloaded. Brush tension should be adjusted through the use of a small spring scales.

Brush Noises

Brush noises are due to vibration or chattering. If due to friction of the brush on the commutator the noise may vary in pitch. The remedy is a change in spring tension, angle of operation or grade of brush. Temporary relief is afforded by lubrication. High mica may cause chattering. The remedy is obvious, the methods already having been discussed. Undercut commutators are sometimes noisy, particularly if the slots are wide or the brushes narrow. The only allowable remedies are changes of tension or angularity, or the use of graphite brushes. Lubrication is not advisable upon slotted commutators.

Successful commutation and commutator maintenance are largely matters of regular inspection and attention to minute causes. A start toward sparking, once attained, leads to rapid deterioration. The easiest way to turn a commutator is to prevent it from becoming rough.

Life-Testing of Incandescent Lamps at Bureau of Standards

The lamps purchased by the Federal Government, amounting to about 1,250,000 annually, are inspected and tested by the Bureau of Standards, Department of Commerce. The specifications under which these lamps are tested are published by the Bureau and are recognized as standard by the manufacturers as well as by the Government. They are used also by many other purchasers of lamps.

The lamps are first inspected for mechanical and physical defects, this being done at the factory by Bureau inspectors. Representative samples are selected and sent to the Bureau where they are burned on life-test at a specified efficiency at which they must give a certain number of hours life, depending upon the kind of lamp. About 5,000 lamps are thus burned on test each year.

For this test care must be taken in the adjustment and regulation of the life-test voltage.

Scientific Paper No. 265, just issued by the Bureau, gives a complete description of the special apparatus and of the methods used in these inspections and tests. Copies of the publication may be obtained free upon application to the Bureau of Standards, Washington, D. C.

Open Type Ball Bearings for Motors and Generators

John T. Bell*

At this time, when the economy and reliability of ball bearings are almost universally admitted, a few observations on anti-friction ball bearing specialization may not be amiss.

That there are special fields for different ball bearings may be unknown to some. Nevertheless, the fact exists—in the bearing field to possibly a greater extent than in other mechanical fields. Some bearings are useful only at slow speeds and do not demand any special care in mounting or manufacture. The next class, embracing a very large number, includes what may be termed, general utility or commercial bearings, in that they may be applied with a reasonable degree of success to practically any work in which the use of anti-friction bearings is desirable. The third and last class—high precision bearings—was brought into existence by the more general understanding of anti-friction bearings and the consequent appreciation of the better results obtainable by proper selection. This type is rapidly growing in favor.

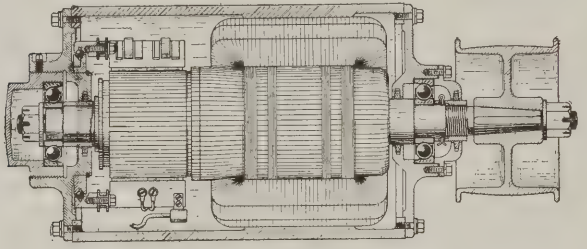
Fig. 1. Axle Lighting Generator Equipped with High Precision Open Type Ball Bearings, Rigidly Mounted, Showing Complete Assembly.

It is the writer's purpose to bring to the reader's attention some of the features which cause the high precision bearing, especially the open type, to commend itself for use in electric motors and generators.

Before entering further into the discussion, a few words describing the essential differences between open and closed type ball bearings may not be amiss. Both types are true radial bearings, carrying their load on a vertical line passing through the points of contact between balls and races, through the center of the ball and the center of the races, at right angles to the axis of rotation of the balls and to the axis of rotation of the bearings.

Speaking generally, the foregoing is the only feature the open and closed type bearings have in common. The closed type bearing is a self-contained unit assembled at the factory and non-separable; while the open type is separable without the use of tools into three parts, or units, namely, outer race, cage with balls, and inner race—each being entirely independent of the others and interchangeable with any corresponding unit of a similar sized bearing. The drawing gives a very clear idea of how this feature can be advantageously made use of in an axle lighting generator or electric motor.

A section of one of the commonly used axle lighting generators is shown in Fig. 1 and this illustration gives a very clear idea of the method of mounting open type ball bearings. In this instance, as in general practice, the inner races are permanently assembled on the armature spindle by the maker and it is unnecessary (except in case of accident) to disturb this original mounting. The outer races are also rigidly mounted, the race on the commutator end being mounted in the grease cap and assembled as a unit with it. It will be seen that this grease cap is threaded, as is also the end plate. This provides for adjustment of the bearing.

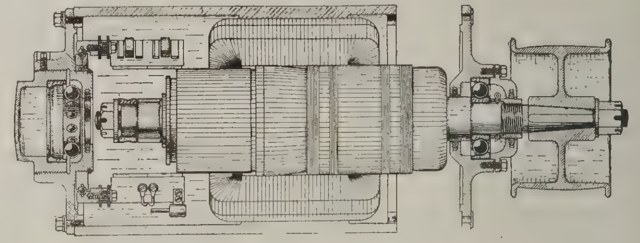
Fig. 2. Axle Lighting Generator with Pulley End Head Loosened and Armature Partially Withdrawn, Showing Easy Disassembly and Ready Accessibility of Open Type Ball Bearings.

To remove the armature, it is only necessary to loosen the pulley and head. A light, steady pull will then suffice to release the armature spindle from the commutator and bearing, the inner race staying on the armature shaft and leaving the outer race with the ball cage assembly in the grease cap, as above described. (Fig. 2.)

Cleaning the bearings is accomplished by wiping off the races, each separately, with a piece of clean waste. The balls and ball cage should next be washed and inspected, and each separate ball as well as the raceways looked over, to insure everything being absolutely clean.

In reassembling, it is only necessary to unscrew the adjustable grease cap on the commutator end, which in turn will release the ball cage. The armature is then put back in its normal running position, the balls with their retainer slipped over the inner race which is still on the armature shaft, the grease cap filled and partially screwed up. Then, while finally screwing up the grease cap and locking it in position, the attendant should rotate the pulley from time to time to see that the armature moves freely. When the grease cap is screwed up so that there is absolutely no end play and the armature shaft can still be rotated freely by hand, the bearing is again properly adjusted.

Before closing—as the writer has referred on one or two occasions in this article to rigid mounting, and knowing that this has not been common practice in the past but is becoming more general—an explanation of his views on the subject may be of interest. In the earlier stage of mounting ball bearings in electric motors and generators, it was the belief of most designers that the axial elongation of armature spindles due to the working rise in temperature was a much larger factor than it has proved to be in practice. It was, therefore, urged, with this belief in view, that one bearing be mounted rigidly and the other one given what is known as a "floating" fit in its housing.

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The term "floating" fit, allowing much latitude and being abused often, permitted a bad condition at the outset to rapidly grow worse with time. Looseness allowed vibration, and vibration in a bearing means noise and wear; a condition was created which was rapidly aggravated as speeds increased—the result being an enlarged bore in the housing accompanied by excessive noise and vibration which in turn decreased the life of the bearing.

Such a condition is absolutely forbidden by the newer practice of mounting both inner and outer races rigidly —which confines all wear within the bearing itself (which is designed to resist wear) and obviates all possibility of wear in the housings, with the resultant rapid deterioration.

A Code for Better Lighting

V

Believing that the proper illumination of railway offices, depots, shops, freight warehouses, docks, etc., is a most important factor in preventing accidents, in producing greater accuracy of workmanship and in increasing labor efficiency, we are reprinting, in short, readable articles, a Code of Lighting, prepared by committees of the Illuminating Engineering Society. This code is a practical summary of information pertaining to the illumination of shops and other work places.

The first article appeared in the January issue.

SECTION VIII. LIGHTING CIRCUITS.—The question of lighting circuits is mentioned here with particular reference to shop conditions, where motor loads are apt to be large in comparison to the energy consumption of electric lamps which are in service. In some cases the proportion of motor load to lighting load is in the ratio of 10 to 1, in others 7 to 1, and so on, and the varying demands on the circuits by motors may greatly affect the lamps. Hence it is important to maintain strictly separate supply circuits for the lamps in order to avoid varying voltage which is apt to result if the motors are connected to the same circuits with the lamps.

Constant Voltage.—In addition to the superior illumination resulting from lamps supplied from constant voltage mains, some types operate with longer life or very much better mechanically when supplied with constant voltage than otherwise. These features will therefore generally more than offset the somewhat greater cost of maintaining separate circuits for each class of service.

SECTION IX. CONTROL OF LAMPS AND ARRANGEMENT OF SWITCHES.—The control of lamps in shop lighting is important in all cases, but specially so where a large number of lamps is used in preference to a small number for a given floor area. For example, where an overhead system of tungsten lamps of small size is used, a large number will, of course, be necessary for a given floor area, and in such cases the number of control circuits may at times seem excessive when planned out for sufficient flexibility of operation. Such circuits, however, in rendering the system more flexible, will be more than paid for by the saving in energy and maintenance due to the turning out of lamps not needed in certain sections of the factory or mill, provided the number of hours per day during which the lamps are used on the average is relatively large, and the differences in daylight intensities over the floor area is also relatively large.

Control Parallel to Windows.—The lamps most distant from the windows will usually be required at times when the natural light near the windows is entirely adequate, thus making it an advantage to arrange the groups of lamps in circuits parallel to the windows. The advantage of this method is further apparent when it is considered that if the lamps are controlled in rows perpendicular to the windows, all lamps in a row will necessarily be on at one time, while a portion only may be required.

Practical Case.—The foregoing statement may be developed into a definite proposition. Thus, to install a single switch may involve, say, $5.00 as its first cost. If ten lamps are to be controlled from a single switch, these ten lamps must obviously either all be turned off at a time or all turned on at a time. An additional switch at a cost of $5.00 will permit either half of these ten lamps being turned off, if not required at certain times when the remaining five are needed. This extra switch may or may not be an economy. Consider, for example, the case where these five lamps are of the 60-watt tungsten type, and that they are turned off by the extra switch on an average of one-half an hour per day while the others are needed, or *vice versa.* In a year's time, the energy saved at 1 cent per kilowatt-hour, will amount to perhaps 50 cents. At this rate it will require ten years for the energy saved to pay for the first cost of the extra switch. This would not be considered a distinct economy. If, however, the energy cost be greater, and more nearly the average under actual conditions, or if the number of hours per day during which a portion only of the lamps will not be used be greater, then these values will be correspondingly modified.

Locating Switches and Controls.—In locating switches or controls in shop aisles, care should be exercised to arrange them systematically—that is, on columns situated on the same side of the aisle and on the same relative side of each column. This plan materially simplifies the finding of switches or controls, by those responsible for turning on and off the lamps, and is particularly important where a given floor space is illuminated by a large number of small or medium-sized lamps distributed uniformly over the ceiling area, a feature which is usually accompanied by the use of a relatively large number of switches or controls.

SECTION X. SYSTEMATIC PROCEDURE SHOULD BE FOLLOWED IN CHANGING A POOR LIGHTING SYSTEM OVER TO AN IMPROVED ARRANGEMENT.—When undertaking the change from an old to a new lighting system, the various forms of illumination which are adapted to shop spaces should be studied, and an investigation made of the various types of electric lamps on the market which are available for the purpose.

Time should be allowed for a study of the given locations to be lighted; for preparing the plans of procedure in the installation of electric lamps and auxiliaries, and for customary delays in the receipt of the necessary supplies and accessories to the work in hand. Altogether, therefore, work of this kind requires considerable time for its completion.

Using the Shop Force.—In large shops a wiring force is sometimes a part of the maintenance division. The work of the wiremen or fitters is likely to be heaviest in the winter due to the dark days. Where this condition exists, there is all the more reason to apportion out new work so as to accomplish it during the months of least wiring and piping repair activity, and further, at that time of the year when employees will be comparatively unaffected by the disturbances usually associated with a change from an old to a new lighting system through possible irregularities in the illumination service while the wiremen or fitters are at work.

Distribution of Expense.—Another feature different from the foregoing viewpoint is in the distribution of the installation cost over a relatively long interval. If, for example, the system is desired for the approaching winter, the complete wiring or piping plans may be drawn up and blocked out into three, four or even more sections, thus spreading the expense over as many months.

Yearly Appropriation.—In some shops a given appropriation may be allotted each year for building equipment. From the standpoint of finance plans, it may thus be desirable to distribute outlays of this nature over the year rather than to concentrate them at any one time. An important consideration in this method of installing lamps, however, is to prepare in as far as possible the complete plans in advance, at least as regards given shop sections, so as to insure a uniform and symmetrical installation as a whole when the component parts are finished.

SECTION XI. REFLECTORS AND THEIR EFFECT ON EFFICIENCY.—A reflector or shade is used in conjunction with a lamp for the purpose of reducing the glare otherwise caused by looking directly into the bare lamp, as well as for the purpose of redirecting the light most effectively to the work.

Reflectors and shades are now obtainable so designed as to be specially adapted to give sizes and types of the smaller and medium-sized line of lamps, and hence care should be used to be sure that both reflectors and lamps are of the correct size in their relation to each other. This is of the utmost importance in securing uniform illumination for a given spacing distance and mounting height of the lamps. For a certain ratio between the spacing and the height of the lamps a reflector can nearly always be selected which will furnish uniform illumination over the working surface.

Function of Reflector.—Owing to the direction of the light from the lamp, nearly all types of lamps, in addition to the downward light, furnish some rays which go upwards and away in other directions from the objects to be illuminated, and are therefore relatively not useful. Furthermore, a bright source in the field of vision causes an involuntary contraction of the pupil of the eye, which is equivalent to a decrease in illumination in so far as the eye is concerned. Hence, while reflectors or shades may at first seem to reduce the amount of light in the upper part of the room, their use actually increases the amount of light in a downward useful direction, and improves the "seeing" due to the better conditions which surround the eyes. The economic function of the reflector, as contrasted with the easier conditions it affords the eyes, is to intercept the otherwise useless or comparatively useless rays which do not ordinarily reach the work, and to reflect them in a useful direction. In performing this function, there is a choice through the design of the reflector in the manner of distributing the light so as to make the illumination on the floor space uniform with certain spacing distances and mounting heights as previously mentioned.

Avoiding Dark Spots.—With the use of lamps for which a large variety of reflectors is available, the proper reflector should therefore be chosen so as to give the desired distribution of light. In other cases, as in the use of the gas or electric arc lamps, where the globe or reflector is usually a fixed part of the lamp, care must be exercised to space the lamps at sufficiently close intervals to insure uniformity of the illumination—that is, a freedom from the relatively dark spaces which exist between lamps when spaced too far apart.

Light Interiors.—With a light ceiling, the reflection of that part of the light which passes through a glass reflector to the ceiling, and which is added to the light thrown downward from the under surface of the reflector, is a factor in building up the intensity of the illumination on the working surface. Great importance is therefore attached to light interior colors, especially on ceilings and the upper portions of walls, both in reinforcing the direct illumination and in giving diffusion, which in turn adds to the amount of light received on the side of a piece of work. It should also be stated that the intensity of the light from bare overhead lamps when measured on the working surface may be increased by as much as 60 per cent through the use of efficient reflectors. This is due to the utilization of the horizontal rays of light, as previously stated, which predominate in the bare lamp, whereas the most effective light in factory and mill work is apt to be that which is directed downward on the working plane.

Glass and Metal Reflectors Compared.—The question is sometimes raised as to the use of glass reflectors in connection with lamps for factory and mill lighting. This question is largely one of economy and maintenance, and it may be answered either in an offhand way or on a basis of practical experience with both types.

In large installations of small units there has been an effort to establish the merits of glass and of metal reflectors by equipping lamps in adjacent bays with glass reflectors in one case and with metal reflectors in the other. It has been found almost invariably that if the choice is left to the workmen and superintendents glass reflectors will be given preference over metal, mainly on account of the added cheerfulness they produce. If, therefore, the first cost and maintenance expense of the glass reflectors is practically the same as with metal, then glass may be employed to advantage.

Reflector Efficiency.—Glass reflectors on the market are capable of producing an amount of illumination equal and even greater in some cases than that produced by the best metal reflectors, and even if the first cost is somewhat higher, the added advantage of glass as opposed to metal is usually sufficient to make the small difference in cost a negligible item. This factor is all the more noticeable when one considers that the reflector itself is a small part of the total cost connected with the wiring or piping of the lamp and its reflector.

Metal reflectors are also available. Some of the advantages of the metal reflector are that it is unbreakable and that accumulations of dust on the outer surface do not decrease efficiency.

Reflector Maintenance.—Regarding the maintenance of glass reflectors under rough factory, mill and shop conditions, it may be stated that glass reflectors are used quite widely with almost a negligible increase due to breakage. Thus, out of the total maintenance cost in one representative installation, it was found that the charges were proportioned as follows:

Renewals, cost of lamps (tungsten)	75 per cent
Renewals, broken glass reflectors	3 per cent
Labor, making renewals and changing reflectors for washing	16 per cent
Labor, reflector washing	2 per cent
Additional indirect charges	4 per cent
Total	100 per cent

Points to Consider.—Reflectors will not be classified here from the commercial standpoint, but the following items should be given consideration in the selection of the type of reflector for factory or mill use:

1. Utilization efficiency: how much does the reflector contribute to the effective illumination on the work?
2. The effect in reducing glare.
3. Natural deterioration with age through accumulations of dust and dirt.
4. Ease in handling and uniformity of manufacture.
5. Physical strength and the absence of projections which may increase the breakage in case of glass reflectors.

A study of the various reflectors on the market with the aid of these items as a basis will determine what reflectors are best adapted to given conditions. Regarding the third item in the foregoing list, it may be stated that under comparative tests in service, the accumulations of dust and dirt on glass reflectors do not seem to be any greater than the coating of dirt which accumulates on the inside of a metal reflector in the same length of time under the same conditions.

Shop Motor Section

The Transformer as a Voltage Booster.

J. H. Wickman*

XVIII.

Cases have often times come up where a generating station generates 2,200 volts at the bus bar, and some certain feeder is to supply some very distant point where it would not be economical to install two transformers, that is, a bank of step up and a bank of step down transformers, such a case can be taken care of by using a transformer as a booster. By refering to Fig 50, which is a diagram of the connections that would be used, the primary (P) of the booster transformer would be connected across the lines A and B, which are on the station side, while the secondary part (S) would be connected in series with one of the main lines. This diagram shows that a transformer is used having a ratio of 10 to 1, or having a boost of 10%, that is 10% added to 2,200 volts will give 2,420 volts. Theoretically this scheme is successful and applicable, but in practice certain conditions must be met as follows:

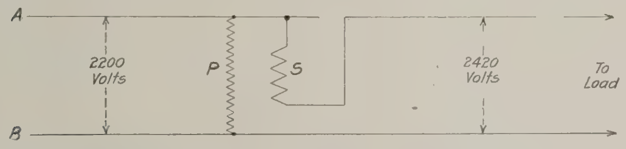

Fig. 50. Diagram of Connections When Using a Transformer as a Voltage Booster.

(1)—Line and boosting transformer should be designed for the same frequency.

(2)—The high tension windings of the boosting transformer should be wound for a voltage nearly equal as that of the line.

(3)—The boosting transformer should have sufficient current carrying capacity so as not to cause undue heating when giving the proper boost voltage from the secondary to line.

Size of Transformer

As an example, assume a line load of 80 k.w., at 95 per cent power factor. What size transformer is required to boost the voltage from 2,200 to 2,420 volts (Referring to diagram.)

$$\frac{80}{.95} = 84.2 \text{ kilovolt-amperes.}$$

Load current would equal $\frac{84.2 \times 1000}{2420}$ =34.8 amperes, primary side.

Booster transformer load would equal $\frac{34.8 \times 220}{1000}$ = 7.65 k.v.a.

Therefore a 10 k.w. transformer would be of sufficient capacity. It should be noted that the secondary voltage or 220 volts, which is one-tenth of the primary voltage, is used in obtaining the transformer load.

Three-Phase Transformation

There are two methods of transforming three-phase currents. One method is to use a three-phase transformer and the other is to use two or three single phase transformers.

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There are many connections used when connecting transformers for three-phase work. As in the alternator or the alternating current motor stator, there may be a star or delta connection which will make quite a difference in the voltages obtained. Referring to the diagram of a three-phase transformer in Fig. 56, if the leads shown at the bottom are numbered from left to right, 1, 2, 3, 4, 5, 6, and if 2, 4 and 6 are connected together and if 1, 3 and 5 are connected to the load we would have a star connection on the secondary side. To get a delta connection we would connect 2 and 3 together as one lead, 1 and 6 as the second and 4 and 5 as the third. It will be seen, therefore, that it is possible to get two different voltages with the same transformer, and that the star voltage will be the square root of three (1.73+) times the delta voltage. The different ways of transforming three-phase current by the use of single phase transformers are shown in Figs. 51 to 55.

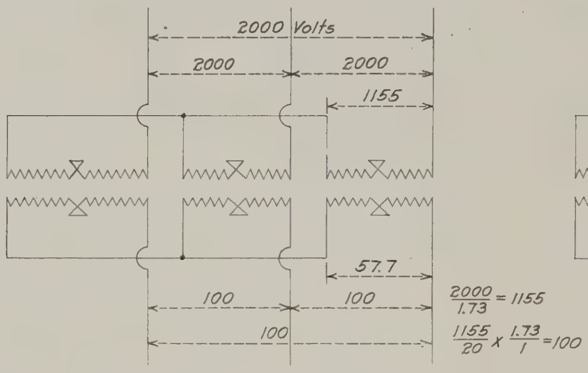


Fig. 51. Primaries and Secondaries Connected in Star.

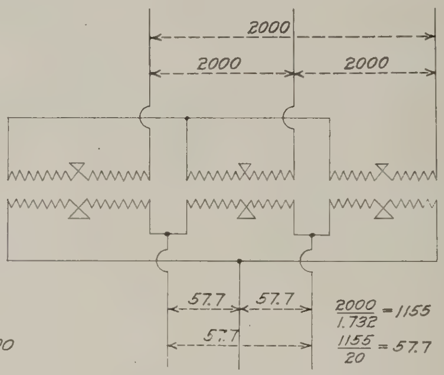


Fig. 52. Primaries Connected Star, Secondaries Connected Delta.

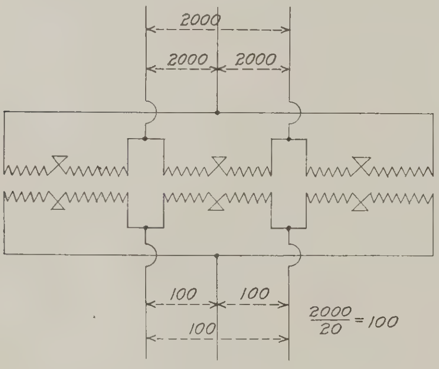


Fig. 53. Primaries and Secondaries Connected Delta.

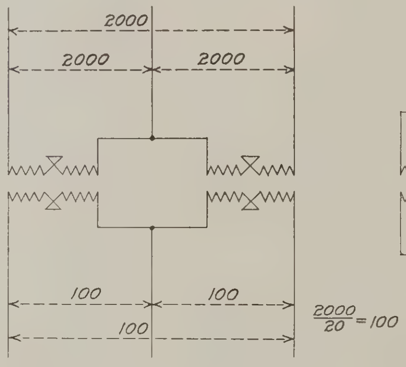


Fig. 54. Primaries and Secondaries Connected Open Delta.

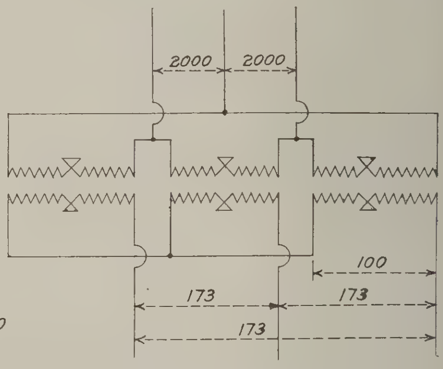


Fig. 55. Primaries Connected Delta and Secondaries Connected Star.

The numbers given in the diagrams represent the voltages between whatever lines they are placed and in each case the ratio of the transformer is considered 20 to 1. In Fig. 51 the primaries of the transformers are connected star, thereby giving a voltage of 2200, divided by the square root of three (1.73+) or 1155 volts across each terminal. As each transformer has a ratio of 20 to 1 we would divide 1155 by 20 which equals 57.7-volts and as the secondary is also connected star we would get a voltage of 57.7x1.732 or 100 volts across the secondary terminals. In Fig. 52 the primaries are connected star so we would have the same voltage across each transformer as in part (a), that is, 1155+volts, and with the same ratio 1155 divided by 20 equals 57.75 volts and as the secondary side is connected delta each terminal would have this voltage.

In Fig. 53 primary and secondary are connected delta, therefore the primary would receive the full line voltage of 2,000 volts, which divided by the transformer ratio of 20 equals 100 volts which would be the secondary voltage.

In Fig 54 is shown the open delta connection which only requires two single phase transformers, each receiving the full line voltage across the primaries, therefore the secondary voltage would be in the same ratio as shown in Fig. 54 or 100 volts. It should be remembered that this connection may be used in case of trouble whenever one of the three delta connected transformers burns out or is otherwise out of commission. Another use made of the open delta connection, is to cut out one transformer at night, when three transformers are being used, so as to save the core and copper losses during the light loads.

The diagram in Fig. 55 shows a delta connected primarily which receives the full line voltage. Dividing this voltage by the transformer ratio of 20 gives 100 volts across each terminal of the secondaries, which, being connected star, gives 100 x 1.732 or 173.2 volts across the secondary lines. It will thus be seen that if it is desired to transmit power for a great distance the voltage can be stepped up by using the same connections as shown in either of these cases. The star connection is used more for very high voltage transmission work than the delta because it raises the voltage higher with the same transformer.

The delta connection is used more in short distant transmissions where there is a large amount of power.

No hard and fast rule could be given where one connection would be used to the exclusion of all others, therefore each installation should receive special consideration. The question often arises whether it is more economical and practical to use two transformers connected in open delta or to use three transformers connected in regular delta. The comparative efficiencies of these as well as the first costs and losses are about equal, however with the open delta, floor space and simplicity of connections are gained. On the other hand, if a bank of three transformers are used instead of two in case of one burning out the other two may be depended on to carry 58 per cent of the total load, while it would be necessary to supply an extra transformer in case one burns out with an open delta connection. Wherever unbalanced voltage conditions are undesirable the open delta is not recommended as the voltage drop is not symmetrical.

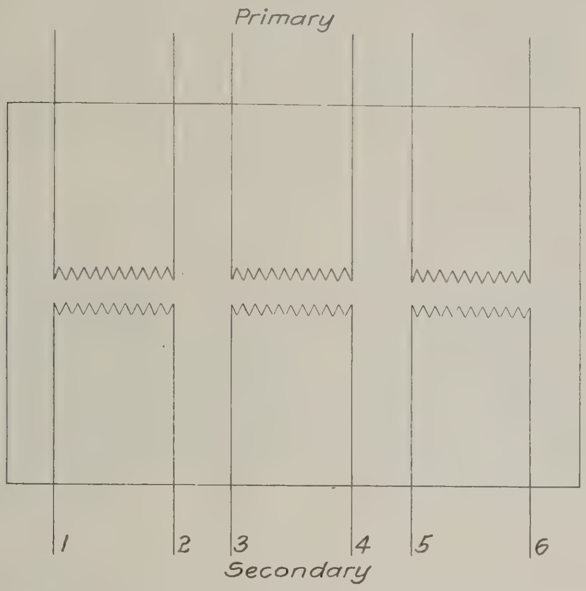


Fig. 56. Schematic Diagram of a Three-Phase Transformer.

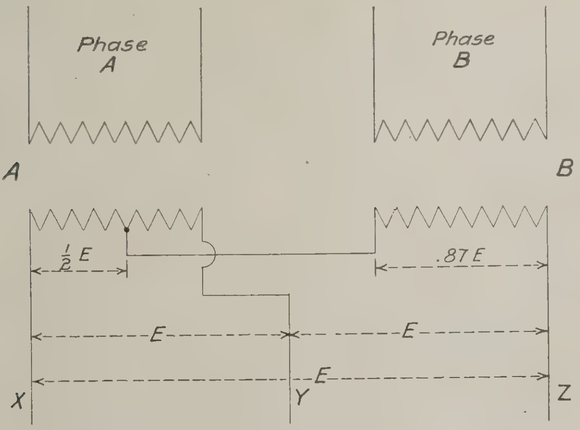


Fig. 57. Schematic Diagram of Scott Connected Transformers for Changing Two-Phase to Three-Phase.

Phase Changing Transformers

In practice it often becomes necessary to change current from one phase to another, that is, from two-phase to three-phase, or vice versa. Special designed transformers are used in making this transformation and the system is called the Scott system after the inventor.

The Scott or T-connection consists of two single-phase transformers which, on the two-phase side, may be connected to a two-phase system in the regular way. On the three-phase side one transformer has a tap at the middle point and the other a tap giving .87 per cent of full voltage. A diagram of connections for Scott connected transformers is shown in Fig. 57, and a vector representation of the three-phase side of this connection is given in Fig. 58. As the total power is $2\ E_2\ I_2$ (2-phase) $=$ $\sqrt{3}\ E_3\ I_3$ (3-phase) it is evident that $I_3 = \frac{2}{\sqrt{3}}\ \frac{E_2\ I_2}{E_3}$ which means that the three-phase current is 16 per cent greater than it would be for straight single or two-phase transformation. Therefore, the total transformer capacity must be 4 per cent greater than the load. In practice it is customary, for the sake of interchangeability, to make the capacity of both transformers 16 per cent greater than the load and to specify for both a 50 per cent and 87 per cent tap on both transformers.

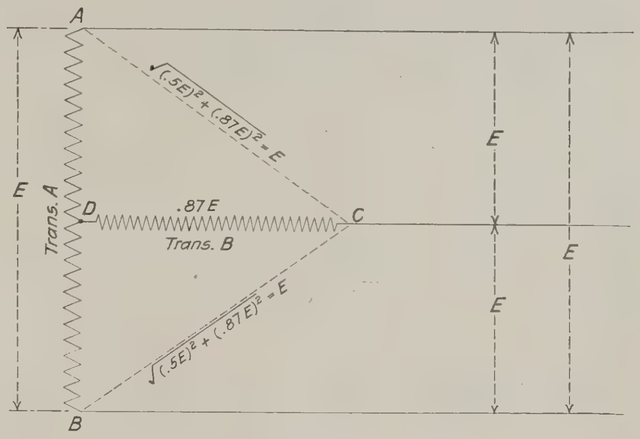


Fig. 58. The Scott Connection Shown Vectorially so as to Show More Clearly Why One Transformer Is Wound to Give Only 87 Per Cent of the Voltage of the Other Transformer.

With this connection both the primary and secondary voltages are balanced if the load is balanced, but any unbalancing of the secondary causes a like amount of unbalancing in the primary and if the load comes on one phase of the secondary it will also come on one phase of the primary.

The reason why one transformer is wound to give only .87 per cent of the voltage of the other transformer or the line voltage may be explained by referring to Fig. 58.

It is clear that the triangle A B C must be equilateral (all angles and all sides equal) if the three line voltages, A B, A C, and B C are to be equal. If we designate each one of these line voltages as E it follows that B C or the voltage of the transformer B must be

$$\sqrt{E^2-(.5E)^2}=\sqrt{E^2}\ (1-.25)=$$
$$E\sqrt{.75}=.866E$$

The power delivered to the three-phase system is, as usual, measured by the two-wattmeter method and is equal to $EI\ \sqrt{3}$.

It is also true that each transformer carries one-half of the total load.

Transformers that are used with the Scott connection can be used as any other transformer, the only difference between them and any other is that the extra tap is taken off in the windings so as to use .866% of the secondary coils. The diagram shown in Fig. 59 will give a better idea of how the connections would look on an actual transformer. It will be noticed that the three-phase leads are numbered 1, 2, 3 and that the .866% tap is represented by X in both transformers A and B. The primary coils, in actual construction, are made up in two coils so as to give different voltage connections; thus by connecting C and D, E and F, H and I, J and K in pairs would give one voltage on a two-phase system, while another connection could be made by connecting D and E together and using C and F as the terminals for one phase and connect I and J together and use H and K as the terminals of the other phase. By using the leads G and L would produce still another voltage. It will also be noted that these transformers A and B are interchangeable, that is, transformer A could be used in the place of B and vice versa.

Emergency Connections

In case of trouble and if it is absolutely necessary to have the phase changing apparatus in operation when one of the regular transformers is out of commission an emergency connection can be made by using two transformers whose ratios are 10 to 1 and 9 to 1 and connect one lead of the one that has the 9 to 1 ratio to the center point of the one having the 10 to 1 ratio. This connection causes a small phase displacement and an unsymmetrical voltage balance, that is, the voltage across any two phases is not exactly equal, but is all right for power connections and although it is better than a shut down it is recommended for emergency purposes only.

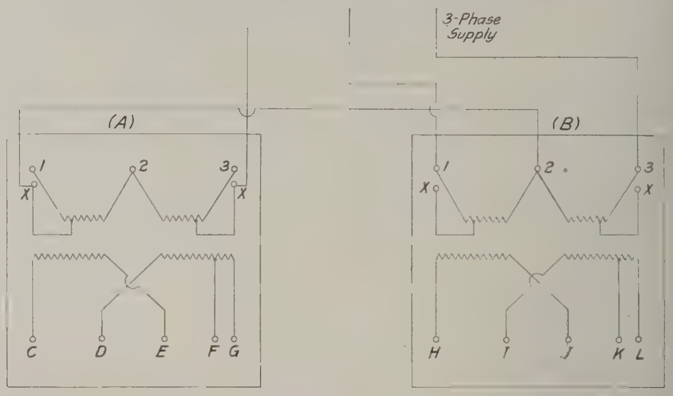


Fig. 59. Diagram Showing Actual Connection of Two Transformers Used for Changing from Three-Phase to Two-Phase

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 51

The U. S. L. Type M Axle Generator

The U. S. L. type M axle generator is typical of the U. S. L. equipments, it being the same as all other types in important details.

The generator is a simple, four-pole, shunt machine, driven from the car axle by means of a belt, as usual. Four brushes are employed which commutate at the four neutral points on the commutator, the two positive brushes and the two negative brushes being connected in parallel. A large handhole is provided on each side of the generator, so that all four brushes may be easily inspected by simply removing the flexible handhole cover, as will be described later.

The type M machine is regularly equipped with any of the standard makes of ball bearings desired. Each ball bearing head is provided with a special oil boss into which is screwed a pipe with a thumb screw cap through which grease may be squirted from a grease gun. One of these oil bosses is shown at R, Fig. 264.

As a general thing the use of a grease gun is not recommended, as with it grease is often forced out of the grease chamber into the machine. In some cases, however, its use may be advisable: For instance, if the bearing on the commutator end is inspected and is found to require a certain amount of grease it would be reasonable to assume that the bearing at the pulley end would require a similar or perhaps a slightly less amount which could be forced in with a grease gun. In this way the work of removing the pulley end bearing cap would be avoided. It should be remembered that, contrary to what would be expected, the pulley end bearing always consumes less grease than the bearing at the commutator end, exactly opposite to the requirements of sleeve bearings. This is, no doubt, caused by the heat from the commutator melting the grease at that end to some extent.

The leads from the generator brushes, together with the positive and negative field leads, are brought to a terminal block S, Fig. 266, which is mounted on the front of the machine. The two generator leads and both field leads are attached to bolts on the outside of the terminal block and from there are taken through a canvas hose to the connecting block on the car body where the negative generator and field leads are connected together.

Automatic Pole Changer

Since a car lighting generator must have a fixed polarity to enable it to charge the storage battery, the reversal in the direction of the car motion necessitates the employment of an automatic pole changer. The U. S. L. automatic pole changer utilizes the friction between the commutator and brushes to shift the position of the latter with each reversal in the direction of rotation. The pole changer consists essentially of a separate brush rig carried on ball bearings which enables it to rotate freely within the housing of the generator. This brush rig is shown removed from the generator casing in Fig. 273.

It is a well known principle that the most perfect commutation with a simple shunt machine can be secured only by giving the brushes a lead. For this reason the brush rig of the U. S. L. automatic pole changer is permitted by the stops T, Fig. 272, to rotate through an angle of 95 degrees, thus securing a lead of 2½ degrees in each position.

Suspension

The generator suspension is of the link type and is provided with two tension springs, one on each side. The generator is attached to the two links by four supporting lugs or feet made in the form of split bearings which, together with all parts of the suspension that are subject to wear, are provided with bushing that may readily be replaced when worn.

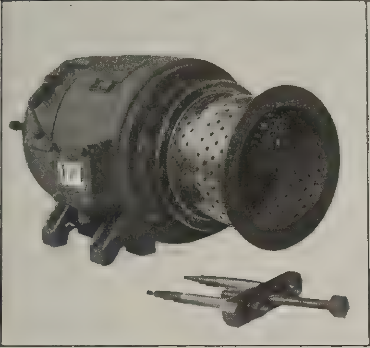


Fig. 263. Pulley End of the U. S. L. Type "M" Axle Generator. The Puller Lying in Front of the Machine is Screwed to the Pulley Web as Shown in Fig. 265. Note the Threads for Various Sizes of Holes on the Two Bolts at the Left.

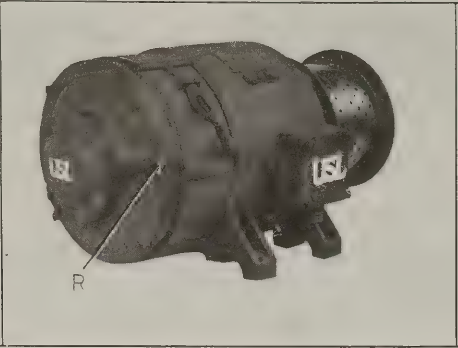


Fig. 264. Another View of the Generator, from the Commutator End Showing the Oil Pipe "R" Through Which It is Possible to Inject Grease into the Ball Bearings with a Grease Gun. There is Another Similar Pipe on the Other End of the Machine.

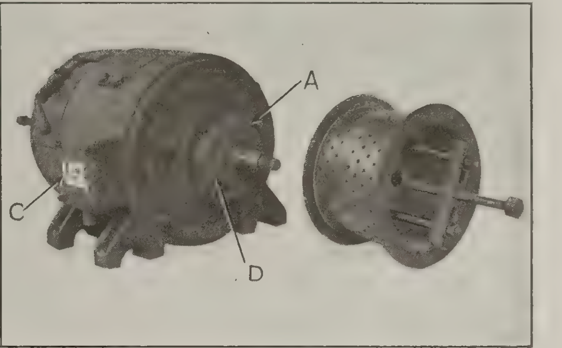


Fig. 265. To Remove the Pulley the Cotter Pin is First Taken from the Castle Nut at the End of the Shaft and the Nut Removed. Then the Pulley Puller is Attached as Shown and the Center Bolt Screwed Down Against the End of the Shaft. This Will Loosen the Pulley So That It May Easily Be Removed by Hand.

Dismantling the Generator

The extent to which a generator is torn down for inspection or repairs depends altogether on what repairs are necessary, but in this lesson we will assume that the machine is to be all torn apart and the reader can then use his own judgment in performing the operations necescary in each individual case of inspection.

Removing the Pulley

It is always the best practice, when removing a pulley, to use a pulley puller whether the machine is on its suspension or removed to the shop. If a hammer and cold chisel is used to force the pulley off, the pulley flange is liable to be broken and at the same time such procedure may spring the armature shaft.

One form of pulley puller that is in general use is shown in front of the machine in Fig. 262. This style of puller consists of a bar of steel with slotted holes at each end and a threaded hole at the center. The slotted holes receive bolts with threads for various diameters of holes at one end, with a regular nut and washer at the other. These two bolts screw into the holes in the pulley web. The center hole takes a bolt which is threaded its entire length and which, when the puller is in position, is screwed down against the end of the shaft thus forcing the pulley off. This center bolt should never be pointed at the end to go into the shaft center as it is essential that the shaft center should not be injured. The pointed bolt grinding into this center would wear it to such an extent that it would be out of true. For this reason it is considered the best practice to finish the forcing bolt off square at the end.

To remove the pulley, apply the pulley puller as shown in Fig. 265, and screw up on the center bolt until the pulley becomes loose on the shaft. It may then be pulled entirely off by hand.

Removing Terminal Box Cover

The terminal box cover C, Fig. 265, should now be removed by unscrewing the four ⅜-in. cap screws. This will expose the four terminals of the block as shown at S, Fig. 266, which should be carefully inspected to see if all connections are tight. Facing the name plate side of the machine, and going from left to right, the terminals are —G, —F, +F, +G. As previously mentioned, the —G and —F leads are not connected together until they are taken to the terminal block on the body of the car. For this reason there are four leads from the machine to this latter terminal block, consisting of the two generator and the two field leads. Formerly the —G and —F were connected together on the generator terminal block, but it was found that under these conditions a break in the negative generator lead between the machine and the car body caused it to operate as a series generator, with the main current going through the field. The excessive current generated at such a time would, of course, cause serious damage to the field, usually a "burn-out."

It is evident that if the connection between the —G and —F was made on the car body instead of at the generator, the trouble described above could not occur, as a break in any of the leads below the car body would open the circuit affected. As an extra safeguard, therefore, this method is employed in the U. S. L. equipments and four leads instead of three go to the car body terminal block. The usual three leads (+G, —F, —G) are then taken from this terminal block to the switchboard.

Removing Ball Bearing Head Cap—Pulley End

The next step in the process of dismantling the generator is to remove the ball bearing head cap, D, Fig. 265, at the pulley end.

After removing the pulley loosen the five ⅜-in. cap screws in this head cap and remove it by gently prying with a screwdriver around the outer edge or by gently tapping with a hammer. It should be noted at this point that the cap has six holes, one of which is designed to receive the dowel pin U, Fig. 266, at the top which makes it an easy matter to re-assemble this cap in the proper position. After the cap screws have been removed it is, of course, necessary to remove the shaft key before the head cap can be taken off.

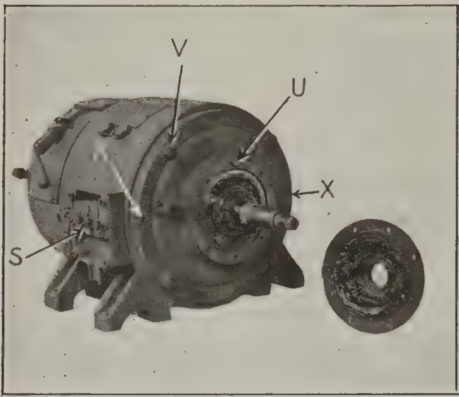


Fig. 266. A View of the Machine After the Ball Bearing Head Cap, at the Pulley End, and the Terminal Box Cover Has Been Removed. The Bearing on This Machine, Which is Shown Exposed, Has Run for Five Months Without Attention and It Will Be Noticed That There is Still Plenty of Grease.

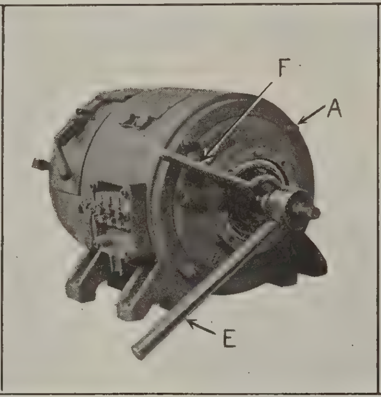


Fig. 267. After the Bearing Head Cap is Removed the Bearing Nut is Loosened with the Spanner Wrench F, While the Shaft is Held Stationary by the Special Wrench E Which is Slipped Over the End of the Shaft and the Shaft Key.

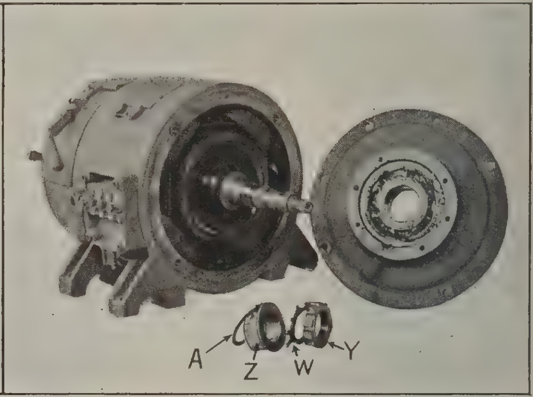


Fig. 268. A View of the Machine Showing Bearing Head at the Pulley End Removed. Before the Cap Screws A, Fig. 267, Were Loosened It Was Necessary to Loosen the Bearing on the Shaft by Removing the Bearing Nut Y, the Lock Plate W, the Bearing Sleeve, the Bearing Spring Washer A. These Parts Are Shown in the Foreground.

Removing Ball Bearing Head Cap—Commutator End

The ball bearing head cap at the commutator end is next removed, in a similar manner, by loosening the five ⅜-in. cap screws. Both bearings are now exposed and the amount of grease in each can be noted so that if it is simply a question of inspecting the bearings to see whether they need grease or not, it is only necessary to remove both head caps as has just been described.

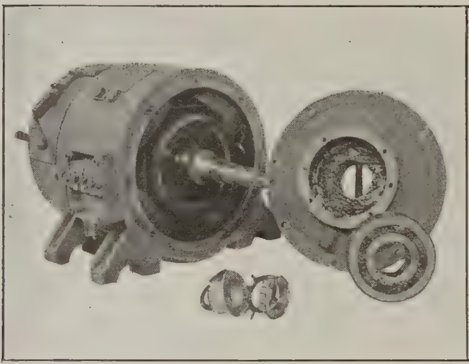


Fig. 269. A View Similar to That Shown in Fig. 268 Except That the Ball Bearing Has Been Removed from the Bearing Head. This Bearing is Easily Removed.

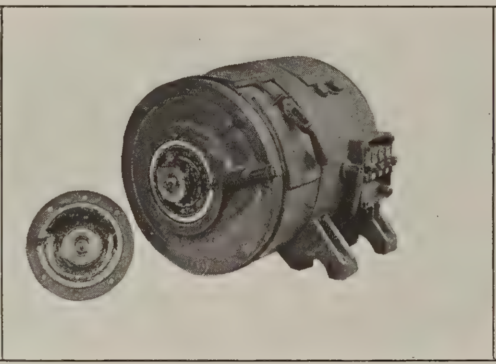


Fig. 270. The Ball Bearing Head Cap Removed from the Commutator End Showing That There is Still a large Amount of Grease in the Bearing After Five Months Operation.

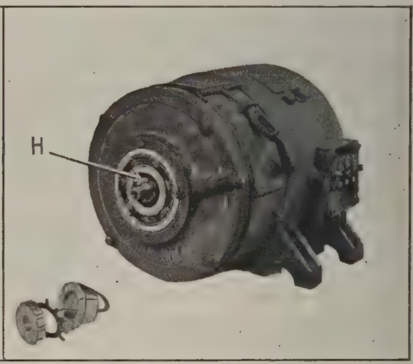


Fig. 271. The Bearing Mounting Parts, Shown in Front of the Machine, Are the Same as Those Removed from the Pulley End.

Removing Ball Bearing Head—Pulley End

The next step in dismantling the generator is to remove the ball bearing head at the pulley end. To do this it is first necessary to loosen up the bearing on the shaft, which is done as follows: First, take a screwdriver, or a small cold chisel and bend up the projection of the bearing lockplate W, Fig. 268, which had been turned down into one of the slots of the lock nut Y, Fig. 268; then adjust the special wrench E, Fig. 267, on the shaft, after inserting the shaft key. This wrench when allowed to rest on the bench or part of the suspension, etc., will keep the armature from turning while the lock nut is being unscrewed with the spanner wrench F, Fig. 267. Before the wrench E is removed the lock nut on the commutator end should also be loosened. After unscrewing the lock nut on the pulley end and removing it and the lockplate from the shaft the ball bearing sleeve Z, Fig. 268, and ball bearing spring washer A, Fig. 268, can be pried out by a screwdriver and also removed. The entire ball bearing head may now be removed by taking out the four ½-in. cap screws A, Fig. 267. It should be noted that at the top of the bearing head there is a hole for the reception of a dowel pin similar to that provided in the ball bearing head cap. In re-assembling, this hole may be easily identified because it is smaller than the others and is not provided with a boss. It should also be noted at this point that the initials of the U. S. Light & Heat Corporation are cast on the bottom of the ball bearing head and that there is a long oil boss cast on the left side of the head facing the machine. By noting these things there should be no trouble in re-assembling the head in the correct manner. In case this lead sticks, two of the cap screws may be screwed into the two holes X, Fig. 266, which will force the lead out.

If desirable the bearing itself may be removed from the ball bearing head before the head is removed from the machine but when completely dismantling the machine the general procedure is to leave the ball bearing in the head on the pulley end until after the head is removed so that there will be no temptation to set the bearing down in sand or cinders. It may also be desirable, when completely dismantling the machine, to remove the ball bearing nut lockplate, sleeve and spring washer from both ends before either ball bearing head is removed.

Removing Ball Bearing Head—Commutator End

Turning to the commutator end, we find that the ball bearing nut has already been loosened, this being done at the same time that the nut on the pulley end was loosened, as already mentioned. The next step then is to unscrew this nut and remove it and the lockplate from the shaft. The outside ball bearing sleeve, with its spring washer, is next removed by gently prying on both sides with a screwdriver. The inside ball bearing sleeve, H, which is only found on the commutator end, is then exposed as shown in Fig. 271. When removing the head at the commutator end it is necessary to take out the bearings, which can easily be done with the fingers, before the head is removed so that the inside ball bearing tapered sleeve H, Fig. 271, can be taken from the shaft. After this inside sleeve has been removed the four ½-in. cap screws, in the head, can be loosened and the head itself removed, which will expose the brush rig R, as shown in Fig. 272.

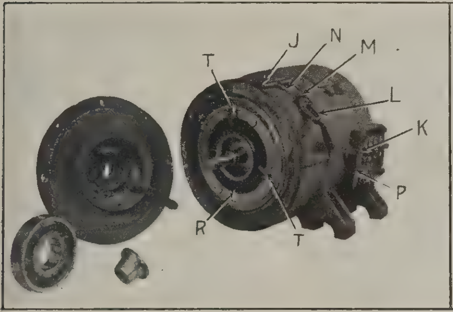


Fig. 272. The Machine with the Bearing Head Removed Showing the Brush Rig "R." The Pole Changer Stops Are Shown at "P." In the Foreground Is the Inside Ball Bearing Sleeve "H" Shown in Fig. 261. This Sleeve Is Found Only on the Commutator End.

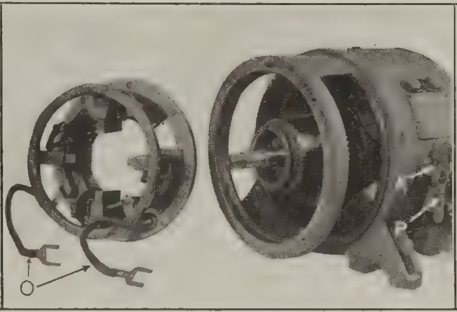


Fig. 273. The Brush Rig and Pole Changer Removed. After the Flexible Leads O Are Loosened from the Terminal Block by Unscrewing the Terminal Block Bolt K with the Wrench P the Brush Rig Can Be Easily Removed.

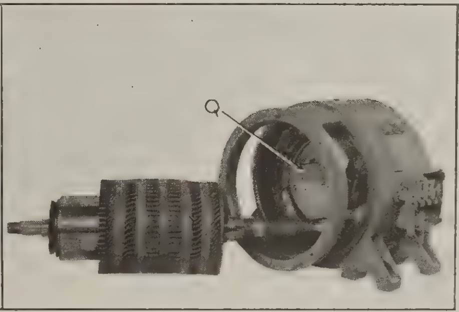


Fig. 274. The Machine Entirely Dismantled with the Armature Removed. If It Is Desired to Paint the Field Coils the Fiber Wedges Q Are Removed. It Is Considered the Best Practice to Remove the Armature from the Pulley End.

Removing the Brush Rig and Pole Changers

The flexible handhole cover J, Fig. 272, is next taken off, which will expose the brushes and the flexible leads which are attached to the brush rig and also to the terminal bolt K. The handhole cover is removed by unscrewing the wrench L until it can be slipped out of the slot M. The T-bolt N is then thrown back and the entire handhole cover removed from the machine frame. The flexible leads O, Fig. 273, are attached to the terminal block by the terminal bolt K, Fig. 273, which can be unscrewed by using the terminal bolt wrench P. There is one of these bolts on each side of the machine and both should be loosened so that both flexible leads will be disconnected from the terminal block. The brush rig can now be easily removed with the hand and the machine will be dismantled as shown in Fig. 273.

Removing the Armature

The usual practice is to remove the armature from the pulley end because the longer shaft extension at this end provides a greater leverage.

Painting the Field Coils

The fiber wedges Q, Fig. 274, should now be removed by gently pounding them with a hammer and the field coils painted with a suitable varnish while they are still in place and connected up. If it should ever become necessary to remove the field coils it is important, when replacing them again, to see that the bottom coil nearest the terminal block should be placed in such a position on the field core that the coil leads point toward the commutator end. The leads from the two adjacent coils should point toward the pulley end and the leads of the coil diametrically opposite; the first one mentioned should point to the commutator end. If care is used to place the coils in this manner they will give the correct polarity when connected up.

Cleaning the Ball Bearing

After removing the ball bearings from their mountings in the ball bearing heads, they should be cleaned so as to remove all grease and dirt. The usual way to clean a bearing is to thoroughly wash it in kerosene or gasolene.

When in operation the outer race of the ball bearing is supposed to "creep" slowly in its mounting so that the outer race will wear evenly. Therefore, when the bearing is removed the inspector should note whether or not the outside surface of the outer race is more or less polished, showing the effect of revolving and wearing slightly in its mounting. If it is suspected that the outer raceway has not been creeping properly it should be investigated and the cause removed.

Overhauling the Brush Rig

In overhauling U. S. L. equipment, it has been found good practice to replace the brush rig and pole changer removed with one which has been previously thoroughly cleaned and overhauled in the shops. When overhauling brush rigs they should be thoroughly cleaned in gasolene and tested for grounds. If the brush holders are not securely attached to the carrier they should be removed, carefully cleaned, insulations set in shellac and re-applied. The outer ball races and balls should then be removed and cleaned and should have a small amount of vaseline applied to them before being re-assembled. It is important that all brush rigs, after removal from the generator, should be fitted with brushes, pig tails and leads which are in good serviceable condition. After the brush rig is re-assembled and applied to the machine, the armature should be revolved in both directions to determine whether the tension of the brush finger springs causes sufficient friction between the brushes and the commutator to carry the brush rigging in both directions to its full travel. It is advisable to repeat this test after the handhole cover has been replaced so as to be sure the leads have not been caught under the handhole cover.

In re-assembling the machine, the operations described above will be repeated in a reverse order. Care should be taken, when bolting the machine on the suspension, to run a wire through the heads of the five-foot cap bolts under each end.

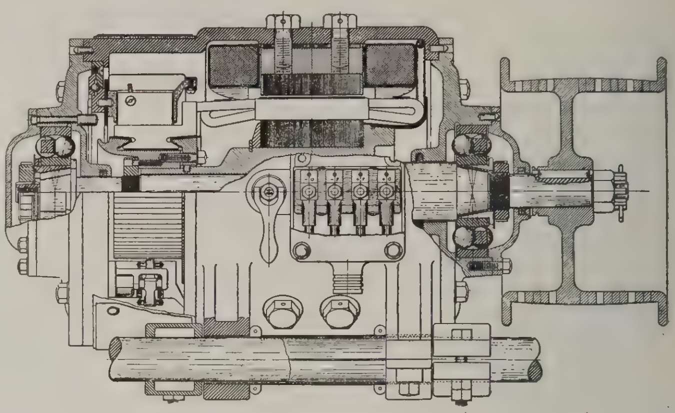


Fig. 275. A Cross-Section View of the U. S. L. Type M Axle Generator Showing Details of Assembly.

The next lesson will be devoted to the U. S. L. panel and ampere hour meter control.

Personal Mention

W. H. Wood

In the electrical department of the Baltimore & Ohio Railroad, W. H. Wood has been appointed superintendent of power plants with headquarters at Baltimore, succeeding T. F. Foltz, resigned.

Mr. Wood comes to the Baltimore & Ohio from the American Writing Paper Company, of Holyoke, Mass., where he had charge of the steam boiler plants. He was born in October, 1875, and graduated from the University of Arts and Sciences in 1898, following which he was connected with the Standard Steel Company, at Burnhan, Pa. From July 1, 1889, to May 1, 1914, he was associated with A. C. Wood, a consulting engineer.

Sydney O. Swenson

The engineering offices of Putnam A. Bates, 2 Rector street, New York, announce that Sydney O. Swenson became a member of that firm on March 15.

Mr. Swenson was electrical engineer of the Kansas City Terminal Railway Company for the past four years, having charge of all electrical work pertaining to the new Union Station and terminal facilities. From August, 1907, to July, 1911, Mr. Swenson was assistant electrical engineer of the Detroit River Tunnel Company, and was engaged on all engineering work in connection with the electrification of the Michigan Central Railroad at Detroit, Michigan and Windsor, Ontario. Previous to joining the Detroit River Tunnel Company Mr. Swenson was with the New York Central and Hudson River Railroad Company for two and one-half years on the electrification of the New York Central at New York. From June, 1899, to March, 1905, Mr. Swenson was in the engineering department of the Commonwealth Edison Company, Chicago, and was engaged on general engineering work in connection with the expansion of this large public utility company. Mr. Swenson was educated in grammar and manual training schools at Chicago, and was graduated from the Electrical Engineering Course, University of Illinois, in 1899.

W. A. Stockbridge

On April 1, W. A. Stockbridge was appointed electrical engineer of the Pennsylvania Lines West, with headquarters at Pittsburgh, Pa., in the office of the general superintendent of motive power.

Mr. Stockbridge was born in 1885 at Fort Wayne, Ind., where he attended the grade schools, graduating from the high school in 1906. In September of the same year he entered Purdue University at Lafayette, Ind., and in the spring of 1910 graduated from the course in electrical engineering. He spent his summer vacations in the maintenance of way department of the Pennsylvania and in the meter testing department of the Fort Wayne Electric Works.

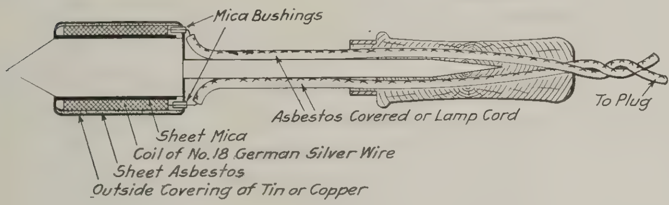
In June, 1910, Mr. Stockbridge entered the service of the Pennsylvania Company at Fort Wayne as a special apprentice, and upon completing his course in January, 1913, was made motive power inspector in charge of car lighting to assist the electrical engineer. In June, 1915, he was made electrical engineer of the Northwest system with headquarters at Fort Wayne, which position he held until he was transferred to the office of the general superintendent of motive power, Pennsylvania Lines West of Pittsburgh, as above noted.

General News Section

A Home-Made Electric Soldering Iron

The illustration shows a home-made electric soldering iron that will give satisfactory results when used on a 32-volt battery circuit.

This electric soldering iron is made as follows: Take an ordinary soldering iron and wrap it with sheet mica. As the mica is very brittle it should be tied in place until the wire is wound around it; next a coil of from 10 to 12 ohms of number 18 or number 20 German silver wire is wound around the mica. The number 18 German silver wire is recommended as this wire, being heavier, will not burn out so quickly as will number 20. The terminals of the German silver wire are connected to either lamp cord or some asbestos covered cord which is taken through the handle and connected to an extension plug. The wire coil is covered with sheet asbestos to hold the heat and over all is wrapped a piece of tin, or thin sheet copper, as a protection for the asbestos. This iron will give perfect results and heats in a very short time and consumes but little current. It can, of course, be applied to any 15-ampere circuit in the car. The writer has used one of these electric soldering irons for all kinds of work and he finds it equal to any soldering iron now on the market.


Mica Bushings
Asbestos Covered or Lamp Cord
To Plug
Sheet Mica
Coil of No. 18 German Silver Wire
Sheet Asbestos
Outside Covering of Tin or Copper

Henry K. Bohlen,
Pullman Company, Charleston, S. C.

Galvanometer Design

Galvanometers are instruments for the detection or measurement of small electric currents or small voltages and are much used in various kinds of electrical testing. The user of such an instrument is concerned with its sensitivity either to current or to voltages, its period, etc.; that is, he is concerned with its performance or operation constants. These necessarily depend upon the intrinsic or construction constants, which in turn depend upon the size, shape, kind of material, etc., of which the parts are made.

The relations between these two sets of constants are of interest to both the user and the maker of galvanometers. They are, however, of more importance to the maker, since they may be made to serve as a basis for predetermining values for the intrinsic constants such as will give previously selected or specified values for the operation constants. In other words, the relations in question will tell him what values the construction constants must have in order that the galvanometer may meet definite performance specifications.

These matters are discussed and illustrated by concrete examples in a paper just published by the Bureau of Standards, Department of Commerce. Copies of the paper, Scientific Paper No. 273, may be had on request addressed to the Director, Bureau of Standards, Washington, D. C.

The Technical Journal as a Catalytic

In chemistry, a catalytic is an agent that brings about a change in a compound while itself remaining unchanged. Thus cane-sugar and water are changed into glucose by the action of sulphuric acid, which is itself unchanged and ready to perform a similar function indefinitely. The mere presence of such an extra substance accelerates chemical change as may be seen by putting a piece of platinum into a mixture of hydrogen and oxygen to form water, or by adding manganese dioxide to heated potassium chlorate to liberate oxygen. A minute amount of material, which adds little or no energy to the reaction, is thus able to bring about tremendous changes.

Such, modestly speaking, is the function of a technical paper. It is the agent whereby men's thoughts are brought into contact and allowed to react upon each other. It is a means to the end of hastening industrial advance.

In order to effectively fulfill this contactor function the journal should be freely furnished with the ideas of the men in the industry. They should regard the journal as employed by them to bring about necessary changes in the business, to stimulate reaction and accelerate progress.

No matter what the difficulty—whether technical in nature and involving unprecedented construction, whether commercial in character and calling for new sales methods, or whether of a sociological kind and tending toward the establishment of better public relations—it can be best met by an exchange of experiences. Mouth—mouth exchange of experience is as limited in scope and inefficient in action as would be dependence upon gold or silver coin as a medium of financial exchange. Just as credit has replaced coin and the clearing-house the individual bank, so the technical journal is available as an active clearing-house of experience.

No editorial staff can be everywhere simultaneously, know everything instinctively and see everything at once. The reader's assistance is needed. The ideal technical journal is one where every reader is a contributor. If every subscriber sent in the news of his job every other subscriber would be benefited. The perfect journal is one in which a reciprocal relation exists between the subscriber and the paper. In order that a magazine may be the voice of an industry the reader should be the eye and ear.

In this respect, the technical journal is a quasi-public utility. Its private ownership is as incidental to the public service as is the private ownership of an electric power company. Experience has demonstrated that such matters can be more effectively conducted by private initiative supplemented by public participation. There is no other means which so adequately and promptly fulfills the requirements for disseminating information as the technical journal.

The editor's duty is to serve the industry which his paper represents. No matter how strong his imagination and how great his ability in thinking of different ways of helping people, he is in a large measure dependent upon the subscriber's assistance.

So, respected reader, we make an earnest plea for your more active participation in the benefits which this journal is capable of conferring upon you. Have you found a better method of cost accounting? Send it to the editor. Are you using a new kink in construction or operation? Share it with others. Is there some question about which you are in doubt? Ask the opinion of those who have already solved it. Have you done something of which you are proud? Let others know of it. Any article, however brief, is welcome if it helps the reader.

A journal is like an association in that the reader gets out of it directly as he contributes to it. The essence of mutual benefit is in reciprocal use. Use the journal as a relay for your ideas, as a clearing-house for your experiences and as a catalyzer of your thoughts. We are then most truly at and in your service.—*Journal of Electricity Power and Gas.*

Tentative Rules for Overhead Electrical Construction in Illinois

The State Public Utilities Commission of Illinois has sent out a pamphlet on this subject which is accompanied by the following letter from R. V. Trather, secretary of the commission, Springfield, Ill.:

"On May 16, 1916, the State Public Utilities Commission of Illinois, will hold a hearing at 9 a. m. in Springfield, for the purpose of ascertaining the views of all interested parties (particularly electric, telephone and telegraph utilities and carriers) relative to the attendant set of tentative rules governing overhead electrical construction in the State of Illinois. Those interested are invited to attend.

"The Commission solicits written comment and criticism regarding subject matter, language, arrangements, requirements and completeness of the rules."

The Standard Underground Cable Co.

The Standard Underground Cable Company announces the following changes in the locations of several of its branch offices:

The Chicago office is now located in the Conway Building, having on May 1 moved from The Rookery, where it was located for many years. The Detroit office has moved from the Free Press Building to the Whitney Building. A new office will shortly be opened in Minneapolis, Minn., in charge of W. J. Weld.

The Portland, Ore., office has been discontinued and a new office opened in the Newhouse Building, Salt Lake City, Utah, in charge of F. W. Wilson.

Electrification in Montreal

The Harbor Commission of the City of Montreal, Canada, in their report for the year ending December 31, 1915, describe a system for the proposed electrification of the railways under their control. These railways, which comprise 45 miles of track, serve the docks and other water front property. The main object of the electrification will be to overcome the smoke nuisance, but in addition, the Commission has decided that the electrification will have the following advantage over steam operation: Economy in operation and maintenance, flexibility of control, availability for immediate service, fewer units required for the same service, reduced fire hazard, lower stand-by losses and the elimination of corrosion of steel and galvanized iron by the acid gases from the locomotive smoke.

W. G. Ross, who was formerly managing director of the Montreal tramways and later president of the Quebec Electric Railway, is president of the Montreal Harbor Commission, which will be in charge of the above described electrification.

New Turbo-Generators for the C. & N. W.

The Chicago & North Western Railway has purchased from the Westinghouse Electric & Manufacturing Company of East Pittsburgh, Pa., two 1500-kw. turbo-generator units, complete with condensers, one 500-kw. turbo generator unit with condensers, and one 50-kw. turbo generator.

This equipment is to be installed in the Calumet Terminal of the Chicago & North Western Railway at Chicago, Ill., and is to be used in operating one of the largest grain elevators in the world.

The U. S. Light and Heat Corporation

On May first the New York office of the U. S. Light & Heat Corporation was removed to the 42nd Street Building, 30 East 42nd Street, from 16 West 61st Street.

The new location is readily accessible to all parts of the city, and will greatly facilitate the conduct of the U. S. Light & Heat Corporation car lighting business.

Mr. E. F. Oates, as manager, is in charge of the New York office.

The Electric Storage Battery Company

On April 1, the Electric Storage Battery Company, Philadelphia, Pa., moved its St. Louis office from the Fullerton building to larger quarters at 1508 Federal Reserve Bank building.

New Offices for the Consolidated Company

The Consolidated Railway Electric Lighting & Equipment Company announce that the main offices of the company have been moved from 11 Pine Street to the Adams Building at 61 Broadway, New York.

The S. K. F. Ball Bearing Company

The S. K. F. Ball Bearing Company announce that after April 20 the main office of the company will be located at Hartford, Conn. The company will, however, retain a small district office at 50 Church street, New York, where the general offices were formerly located.

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Belt Life With Body Hung Axle Generators

The effect on belt life of the body suspended axle generator which is now coming into universal use is a question of intense interest to all railway electrical engineers who are using or who are contemplating the use of this kind of suspension.

The two standard methods of driving body-suspended generators are the one employed by all American manufacturers, in which the belt tension is maintained by a spring to such a value as to cause the machine to accurately follow all variations in train speed, and the one employed by the manufacturers of the Stone equipments, where the belt is allowed to slip over the axle pulley after a predetermined speed has been reached, at which time a predetermined output is being delivered.

As far as the belt is concerned both systems have their advantages. In the system first mentioned the initial tension of the belt is high, but, on the other hand, it does not normally slip over the pulley face for which reason it would seem that the actual wearing effect on the belt would be less; in the second system where the belt is allowed to slip the initial belt tension is not nearly as high so that the internal strains in the belt are no doubt, at a minimum, which fact should at least compensate for the wearing action on the face of the belt due to its slipping over the pulley face.

As in all matters of this kind it is difficult to arrive at a correct comparison by simply theorizing, it being necessary, in the final analysis, to depend on actual experience based on results in service. In this connection an article appearing elsewhere in this issue by E. S. M. Macnab, describing some belt tests on the Canadian Pacific made on machines driven by both the methods described above should be of interest. We cannot say that the results of these tests form a basis for a fair comparison between the two methods of driving body-suspended axle generators as they were not made for that purpose, being made rather to determine which make and construction of belt was best adapted to the service in question. On the other hand, it seems that the favorable showing of the belt used with the generators controlled by the slipping belt method nullifies the natural and popular belief that such an unethical method of control must be excessively hard on the belt.

The mileage obtained with belts used with the free speed machines, where the belt tension is controlled with springs, is also exceptionally good. The average life for such belts being in this case about 60,000 miles. If we can take these tests as an indication of how the body-suspended machines are going to treat their belts we surely have little cause for worry.

Passenger Car Illumination

The day is past when the design of a lighting system for passenger cars can be taken care of by drawing in a few circuits and fixtures with a good-enough-let-it-go-at-that. Car lighting and car illumination has become an art, and is more and more being considered as such. Today plans for the lighting installation are made with as much care and forethought as are plans for the car itself, the object being always to provide an installation that will give the correct illumination for the service intended under all conditions, that will have the lowest first cost compatible with high efficiency and pleasing appearance and that will insure a minimum cost for maintenance.

On considering the amount of illumination to be obtained in certain places in the car it is not enough to simply plan on providing a certain number of foot candles,—the quality, diffusion and distribution of the light must be given their share of attention. Probably the greatest evil of the older systems of car illumination aside from the general low illumination value was the glaring effect of the unshaded lamp filament and the improper location of light units in the field of vision. In some cases the opposite effect was reached by locating all lighting units entirely out of the field of vision, thus causing a cold and depressing effect.

The best interests of economy are generally fulfilled by employing as few fixtures as possible, the best practice probably being to locate single light fixtures down the center of the car body which not only means low first cost but also provides that the maintenance cost for lamp renewals, reflector breakage, and reflector cleaning, etc., will be a minimum. The illumination with such a system, as proven by many tests, is practically as good as can be obtained with any other system.

An interesting description of a new system for lighting Pullman cars appears on another page of this issue. The installation should be of special interest as the new 100-watt Mazda C lamps are employed.

The Illuminating Engineering Lecture Course

During the week September 21 to 28, 1916, the Illuminating Engineering Society in co-operation with the University of Pennsylvania will give a course of lectures on illuminating engineering at the Engineering building, University of Pennsylvania, Philadelphia.

These lectures will be similar in many respects to the course given by the same society in co-operation with Johns Hopkins University in 1910. The scope of the new course is intended to be somewhat different from that of the first course which dealt primarily with the principles of the art and their applications; the present course is intended primarily as a course of study based on the practical application of these principles to the work of illuminating engineering as carried on today by the latest methods with the most recent equipment.

The nineteen or twenty lectures to be given cover the following subjects of especial interest to railway electrical engineers:

1. Principles of interior illumination.
2. Principles of exterior illumination.
3. Recent developments in electric lighting appliances.
4. Modern lighting accessories.
5. The lighting of factory, mills and shops.
6. Train lighting.
7. Street lighting.
8. The lighting of yards, docks and other outside work.
9. Headlights, searchlights and projectors.

Other lectures on color in lighting, the lighting of offices, stores and show-windows, schools, auditorium, and libraries, the lighting of the home and building exteriors, expositions and pageant lighting should be of general interest.

In connection with the lectures will be an exposition at the University of Pennsylvania of the latest developments in illuminating appliances, including lamp photometer together with novel lighting installations and applications which should be of great educational value. An inspection tour is also being arranged to be included with the lecture course which is expected to be of particular interest and value for those who come from a distance; it will include a visit to a manufacturing establishment, laboratories and other points of technical interest in Philadelphia.

The nominal tuition fee of twenty-five dollars will be charged for admission to all lectures and functions associated with the lecture course, the money to be collected in this way to be used entirely for the expenses incurred. Each ticket to the lecture course will, in addition to the above, entitle each holder to a partial or entire reprint of the 1910 lectures together with reprints of the new lectures.

This is an opportunity that should not be missed by the electrical engineers of the railroads in view of the large amount of varied illumination work that comes under their direction.

Letters to the Editor

Should Trolley Poles Be Set With a Rake?

SAULT & STE. MARIE,, Mich.

TO THE EDITOR:

It is a well-known fact that many roads who are using electrical energy for motive power are building their overhead lines by setting the poles with a certain rake, from six inches to two feet.

It seems to me that a line constructed with poles set with a rake gives a very poor impression. Such a line even if new, always has the appearance of being thirty or more years old.

I saw the first line built with poles set with a rake in London, England, on a street railway line. These poles were all of good manufacture and were made of cast steel with cast iron bases. The rake was about six inches and the poles were set without guy-wires. A line built like that, however, makes a very bad impression and spoils the appearance of the street.

Now referring to the article on the Chicago, Milwaukee & St. Paul electrification, in the May issue of the *Railway Electrical Engineer;* Fig. 2, on page 345, shows guyed poles set with a rake. Therefore, I would like to ask some of the readers who have had more experience in pole setting what advantage is to be gained by setting poles with a rake, and if a guyed pole set with a rake will stand more load under ordinary conditions than a guyed but straight set pole.

It seems that it would be better if the designing engineer, when designing a pole line for a certain load, would set the poles straight, because of the better impression that this type of construction would make on the traveling public.

J. G. KOPPEL.

Semi-Annual Convention A. R. E. E.

Reports of Committees

Meeting will be called to order at 9:30 A. M., June 16, at the Hotel Denis, Atlantic City.

The Order of Business

Consideration of Minutes of Last Meeting.
Address of President.
Report of Secretary-Treasurer.
Unfinished Business.
New Business.
Report of Standing Committees.
Report of Special Committees.
Paper on Maintenance of Storage Batteries by Mr. Ernest Lunn, Pullman Co.
Paper on Method of Cost Keeping for Railway Shop Power Plants by Mr. E. Wanamaker, C. R. I. & P. R. R.
Miscellaneous Business.
Adjournment.

Illumination

The work undertaken by your committee for this year has been divided into two subjects with sub-committees appointed to handle each:

First—Sub-committee "A" which will carry on further investigation of subject of lighting of railroad yards with the presentation of recommendations as to proper methods to secure adequate illumination of railway classification yards.

Second—Sub-committee "B" which will handle the changes in the rating of train lighting lamps and revision of incandescent lamp specifications.

With reference to revision of lamp specifications the executive committee has assigned to the illumination committee as part of its regular duties the work of making such revisions in lamp specifications as necessary each year in order to keep them up to date.

Sub-committee "A" has completed its investigation of the subject of yard lighting and at annual meeting report will be presented covering definite recommendations relative to adequate and proper illumination of railroad classification yards.

Sub-committee "B" has completed investigation of questions of changes in the rating of train lighting lamps and in this connection desires to submit the following report:

Sub-Committee on Rating of Train Lighting Lamps

It was recommended last year that all improvement in train lighting lamps should be allowed to go into increased candle power until an efficiency of approximately one watt per candle was reached, when the rating should be changed to a spherical candle-power basis and further improvements allowed to go into decreased wattage. The possibility of introducing the gas-filled lamp into this service at an early date makes it necessary to give this subject immediate attention.

A survey was conducted to determine whether the railroads are prepared to accept a change of this kind. The secretary addressed a circular letter to the principal railroads and the replies, together with the questions asked, are as follows:

(1) Do you favor changing the rate of train lighting lamps from a mean horizontal to a mean spherical basis?

In favor—Unqualified	8,551	
Qualified	33	
Total		8,584
In opposition—Unqualified	69	
Qualified	690	
Total		759
Total cars voting		9,343

(2) Do you object to the slight increase in wattage incidental to this change?

In favor—Unqualified	8,595
In opposition—Unqualified	1,085
Total cars voting	9,670

(3) Do you favor the use of the gas-filled lamp at an increase in initial cost?

In favor—Unqualified	3,197	
Qualified	3,605	
Total		6,802
In opposition—Unqualified		1,783
Total cars voting		8,585

(4) Do you have any demand for a 20 M. S. C. P. lamp in the 25-34-volt range? This lamp cannot be furnished in the 57-65-volt range.

In favor—Unqualified	932	
Qualified	586	
Total		1,518
In opposition—Unqualified		7,979
Total cars voting		9,497

The present train lighting schedule is as follows:

Size of lamp in watts	Bulb designation		Mean Hor. C. P.		Mean Spher. C. P.		Lumens	
	Straight side	Round	Total	Watts per	Total	Watts per	Total	Per watt
10	S-17	G-18½	8.55	1.17	6.67	1.50	83.8	8.38
15	S-17	G-18½	13.39	1.12	10.44	1.44	131.2	8.75
20	S-17	G-18½	18.18	1.10	14.18	1.41	178.2	8.91
25	S-19	G-18½	22.73	1.10	17.73	1.41	222.8	8.91
40	S-19	G-30	40.00	1.00	31.20	1.28	392.1	9.80
75	....	G-30	78.95	.95	64.74	1.16	813.5	10.85

It is the general consensus of opinion that while it is desirable to change the rating of these lamps to a spherical basis, no changes in efficiency should be made which will necessitate changes in manufacturing processes. It is also deemed wise to fix inspection limits in terms of lumens rather than mean spherical candle power. The acceptance of these two proposals requires that the actual light value of each lamp shall be fixed in lumens while the rated size, or name under which the lamp is purchased, shall be given in spherical candle power values. The proposed immediate change is as follows:

Size of lamp		Lumens		Mean Spher. C. P.		Actual total watts
In watts	In m.s.c.p.	Total	Per watt	Total	Watts per	
10	7	85	8.38	6.76	1.50	10.1
15	10	130	8.75	10.35	1.44	14.9
20	15	180	8.91	14.32	1.41	20.2
25	20	220	8.91	17.50	1.41	24.7
40	40	390	9.80	31.03	1.28	40.8
75	65	815	10.85	64.85	1.16	75.1

These values are so close to present values that no changes in manufacturing processes are necessary. The introduction of the gas-filled lamp will make it necessary to extend this schedule and at the same time to rearrange some of the present values. The following schedules are proposed in this connection:

25-34 Volt Range

Size of lamp in m.s.c.p.	Lumens		Mean Spher. C.P.		Actual total watts	Bulb designation	Length over all. Inches	Light center length
	Total	Per watt	Total	Watts per				
7	85	.....	.....	....	....	S-17	4⅝	....
10	125	.....	.....	....	....	......	....	....
15	175	.....	.....	....	....	......	....	....
20	250	.....	.....	....	....	......	....	....
40	500	12.57	39.79	1.00	39.8	PS-20	3½ to 4	5 to 5½
80	1,000	14.80	79.58	.85	67.6	PS-22	4 5/16	6⅛
120	1,500	14.80	119.36	.85	101.3	PS-25	5 3/16	7⅛

57-65 Volt Range

Size of lamp in m.s.c.p.	Lumens		Mean Spher. C.P.		Actual total watts	Bulb designation	Length over all. Inches.	Light center length
	Total	Per watt	Total	Watts per				
7	85	.....	.....	....	....	S-17	4⅝	....
10	125	.....	.....	....	....	S-17	4⅝	....
15	175	.....	.....	....	....	S-17	4⅝	....
20	250	.....	.....	....	....	......	....	....
40	500	10.90	39.79	1.15	45.9	PS-20	3½ to 4	5 to 5½
80	1,000	13.20	79.58	.95	75.7	PS-22	4 5/16	6⅛
120	1,500	13.20	119.36	.95	113.6	PS-25	5 3/16	7⅛

It is expected that all lamps in the 25-34 volt range, except the 7 candle power, will eventually be furnished in the gas-filled type. In the 57-65 volt range all but the 7.10 and 15 candle power lamps will probably be furnished in the gas-filled type. It is suggested that when a gas-filled lamp is available in the 25-34 volt range and not in the 57-65 volt range, the corresponding vacuum lamp in 57-65 volt range will at that time be changed in construction to give the total lumens specified above. There is practically no demand for the present 75-watt lamp and the demand for the proposed 80 candle power lamp will also probably be very limited. For this reason it is proposed to drop these lamps from the published schedules with the understanding that the manufacturers will hold themselves ready at all times to furnish the 80 candle power gas-filled lamp in case any railroad desires to use it. If the demand for it increases it can be placed in the schedule at any time.

Respectfully submitted.

L. S. Billau, B. & O. R. R., chairman.
Jos. A. Andreucetti, C. & N. W. Ry.
J. L. Minick, Penn. R. R.
J. E. Gardner, C. B. & Q. R. R.
H. C. Meloy, N. Y. C. R. R.
G. O. Moores, B. & O. R. R.
J. R. Sloan, Penn. R. R.
C. W. Bender, National Electric Lamp Assn.
L. C. Doane, Regent-Ivanhoe Works.
W. H. Rolison, Westinghouse Lamp Co.
H. Schroeder, General Electric Co.
L. C. Porter, General Electric Co.

Shop Practice

Sub-Committee on Compressed Air and Its Application

Test of Air Pipe

Tests are being made on compressed air piping systems in various shops to find the amount of leakage obtained in actual practice, and to determine the extent that this leakage can be cut down when the piping system is given careful supervision.

Distributing Systems

The committee is planning to work up a diagrammatic plan, showing a sample air piping system for a railroad shop, also showing a case where two or more electric driven air compressors can be operated to advantage in preference to one larger compressor.

Shop Tools

The Committee is taking it up with various manufacturers of electric and pneumatic shop tools with the idea of working up a list of such tools, showing relative advantage and disadvantage of electric and pneumatic tools of the various types.

Respectfully submitted.

J. E. Gardner, C. B. & Q. R. R., Chairman,
H. R. Bucks, O. S. L. R. R.
T. F. Foltz, Washington Term. Co.
L. M. Gazin, Santa Fe R. R.
H. C. Meloy, N. Y. C. R. R.
R. M. Pachaly, C. R. I. & P. R. R.

Sub-Committee on Electric Welding

Your committee has been unable to get a full committee meeting or an expression from all the members yet on this sub-committee. The substance on the report which we have in mind is as follows:

Basic Principles of Arc Welding

1. Visible arc.
2. Electrode.
3. Polarity for welding.
4. The energy.
   (a) Density.
   (b) Comparative data of arc and other heat producers.

Elementary Metalogy of Arc Welding Process

1. What happens to steel when it is melted and cooled.
2. The effect of the arc on the metal filled into the weld.

Application of Arc Welding in Railroad Shops

1. Filling in operation (practical points).
2. Straight welding operations (practical points).
3. Relative cost data.

Arc Welding Equipment

1. Capacity required.
2. Different types in use.
   (a) Portable.
   (b) Stationary.

The probable direction of development of application process and design of equipment.

Protective shields (necessity of same).

Shop organization as to selection of competent or expert welder in charge to instruct operators.

Standardization of Operation

1. Length of time, different operations.
2. Amount of current consumed on different operations.
3. Kinds of electrodes to be used.

In our opinion, this will cover the entire field of electric arc welding. We have not considered spot welding, as we have been unable to find out whether this would be used to any great advantage in a railroad shop. However, if the committee as a whole considers it advisable that we should investigate spot welding, in this year's report, we can do so.

We presume that in your progress report for the semi-annual convention, you are inviting further suggestions from the members so as to be able to cover the field to the satisfaction of all members.

Respectfully submitted.
H. C. Meloy, N. Y. C. R. R.,
Secretary, Sub-Committee.
S. T. Sikes, S. P. R. R.
D. C. Wilson, U. P. R. R.
Robert Kinkead, Lincoln Electric Co.

Sub-Committee on Maintenance and Repairs

Work has been taken up relative to the maintenance and repairs of direct current equipment. This work will not be confined directly to maintenance and repairs, however, but will speak of the best application methods that can be made with the different classes of direct current motors, as, for example, the series wound motor is best adapted for hoisting purposes, the shunt wound for steady speed, etc., stating what kinds of machinery throughout the railroad shops would be equipped with the different types.

Work has also been started along the same lines with alternating current equipment and comparative costs of different methods will be mentioned as well as comparative costs of group and individual driven machinery.

The maintenance, repairs, costs, etc., of illuminating with different lighting systems has also been taken up and fully covered in an illustrated manner.

All of the work on the following has been completed: Under the head of turntables and motors the question of sizes to be used is covered, actual test data has been taken in the field showing the amount of current required for the larger tables and the size of motors in H.P. required to operate them; also recommendations as to the types of motors to be used on tables, using the theory that the turntable requires a motor with a high starting torque more than one of high efficiency. Under this same head it has been our endeavor to fully cover the repairs that have been necessary with the high resistance slip ring motor to bring it up to a standard where it can be depended on for service and to also give in detail in an illustrated manner the changes necessary and experiences with the underground contactor system. It is our opinion and recommendation that this can be standardized after the next annual convention.

The subject of lubrication has been discussed to some extent, including the factors of velocity of shafting, weights, composition of bearing metals and viscosity of the lubricant, and in a limited way the kinds of oils and greases which are best for machinery of different speeds having a rotating element of a certain weight.

The maintenance of the electrical equipment connected with the Gas Electric Car has now entered the field of the railroads and it has been our intention to speak of the different parts of these cars that have caused trouble and to give suggestions for remedying these troubles, thereby lessening the maintenance costs.

The electrical driven air compressor is discussed in a limited way also, including parts and times for the inspection in order to keep the electrical as well as the mechanical parts in first-class order.

The manner of handling complaints of excessive meter bills and testing of outside public service companies' meters in a manner that will not cause any friction, or will not take much time of one man, is taken up in detail, as we consider that from this one source a great saving in money can often be saved for the railroads as well as keeping the railroads' meters in first-class order, should they be the ones who are selling power.

These several different subjects mentioned conclude the work to be presented at the next convention, if they meet the approval of the association.

Respectfully submitted,
J. H. Wickman, I. C. R. R., chairman.
J. H. Edwards, C. R. I. & P. R. R.
J. H. Wright, C. B. & Q. R. R.
J. C. McElree, I. C. R. R.

Anti-Friction Bearings for Motor Equipment

Your committee held a meeting on March 24, in Room 856, Transportation Building, Chicago. The following members were present:

C. R. Gillman, C. M. & St. P. Ry.; H. C. Meloy, N. Y. C. R. R.; A. J. Farrelly, C. & N. W. Ry.; J. McElree, I. C. R. R.; E. Wanamaker, C. R. I. & P. Ry.; W. O. Doud, C.E., Chicago, Ill.; W. A. Hancock, C. of G. Ry.; all of the Association's representatives.

The following Manufacturers' representatives were present:

F. S. Hickok, Ridgeway Dynamo and Engine Co.; R. M. Gaston, of the George P. Nichols & Bros., Chicago; J. T. R. Bell, of the Norma Co., New York City; J. G. Cooley, of the Standard Roller Bearing Co., Philadelphia; A. E. Garland, Fairbanks-Morse Co., Chicago; M. O. Southworth, of the Fairbanks-Morse Co., Chicago; Fraser Jeffery, of the Allis-Chalmers Co.; B. F. Bilsland, General Electric Co.; Mr. C. H. Roth, Roth Bros. & Co., representing the Electric Power Club; W. L. Batt, Hess-Bright Manufacturing Co.; Edward Wray, of the Railway Electrical Engineers; Joe Andreucetti and C. J. Causland, as chairman.

Considerable discussion took place on the subject of **ANTI-FRICTION BEARINGS** and of the thirty-three of the manufacturers notified to attend the meeting, twenty-three reported as favorably impressed with the question of adopting the standard ball and roller bearing sizes for motor equipment; the remaining ten referred to the Electric Power Club for consideration.

Mr. Wray, of the *Railway Electrical Engineer,* moved that the Electric Power Club be requested by our secretary to appoint a committee to confer with this committee and also with representatives of all ball and roller bearing manufacturers to investigate the subject of the use of ball and roller bearing for electric motors for railway service, with a view to standardizing on sizes of all ball and roller bearings to accommodate the various sizes of motors at the various speeds. The motion was seconded by H. C. Meloy and carried by vote.

On date of April 3 our secretary appointed the following members of the Ball Bearing Manufacturers to establish a committee on the question of the Ball or Roller Bearing for Motor Equipment:

Mr. W. L. Batt, Hess-Bright Manufacturing Co.; Walther Noeim, of the Norma Co. of America; J. G. Cooley, of the Standard Roller Bearing Co.; H. H. Gildner, of the S. K. F. Ball Bearing Company; Mr. D. Davis, of the Fafnir Bearing Co., Chicago.

The committee representing ball bearing companies, held a meeting on April 13, in Philadelphia, and suggested that nothing could be definitely decided on the size of ball bearings until the Standardization Committee of the Electric Power Club came to some definite understanding on shaft sizes and housing fits.

On May 1, 2 and 3 T. V. Buckwalter, Penn. R. R., H. C. Meloy, N. Y. C., and Edward Wray, *Railway Electrical Engineer,* representing the Committee on Standard Ball or Roller Bearings for the Association of Railway Electrical Engineers at Hot Springs, Va., were notified to attend the meeting of the Standardization Committee of the Electric Power Club and were given the opportunity of explaining the matter on which standards are desired.

Nothing further has been done, and the commitee is waiting for a call from the Standardization Committee of the Electric Power Club to co-operate on this question.

C. J. Causland, Penn. R. R., chairman.
C. R. Gillman, C. M. & St. P. Ry.
H. C. Meloy, N. Y. C. R. R.
A. J. Farrelly, C. & N. W. Ry.
J. McElree, I. C. R. R.
E. Wanamaker, C. R. I. & P. R. R.
W. O. Doud, C.E., Chicago, Ill.
L. Gazin, A. T. & S. Fe Ry.
J. A. Shaw, C. P. R. R.
W. A. Hancock, C. of G. Ry.
Edward Wray, *Ry. Elec. Eng.*

Crane, Turntable and Transfer Table Motors

The committee held meetings on February 12 and March 24. It was decided that the first thing to consider was taking up with the different motor manufacturers the question of construction along the following lines:

1. Motor rating: Standard motor speed of 600, 750 and 900 R.P.M., corresponding to full load speed of D.C. motors, and synchronous speed for A.C. motors, except in case of the 750 R.P.M., 60 cycle, A.C. motor. For A.C. motors in intermittent service, we suggest 1,200 R.P.M., but not for general use.

2. Temperature rating on a basis of 50 degrees Centigrade rise by the thermometer method for open type motors, and 50 degrees rise for enclosed type motors on a one-half hour run at full load.

3. Torque rating on starting should be from 7 to 10 times the full load torque.

4. Standard dimensions for D.C. motors on—
   (a) Height of shaft above motor base,
   (b) Bolt hole dimension and spacing in four directions,
   (c) Shaft diameter and shaft extension outside of the bearing,
   (d) Keys and keyways.

5. Standard dimensions for D.C. motors on—
   (a) Height of shaft above motor base,
   (b) Bolt hole dimension and spacing in four directions,
   (c) Shaft diameter and shaft extension outside of the bearing,
   (d) Keys and keyways.

6. Standard sizes of anti-friction bearings for various sizes of motors used on traveling cranes. We suggest that this standardization be established by collaboration with the motor bearing committee of the Association of Railway Electrical Engineers.

The association invites the co-operation of the Electric Power Club in bringing about these standards.

The sub-committee appointed to take this question up with the Power Club representing different manufacturers at their meeting held at Hot Springs, May 1 and 2, report that the Power Club representatives seemed very friendly towards the proposition of standardizing on crane motors, and the question has been referred to the committee on motor applications, which, I understand, they will take into consideration and report at a later date relative to a joint meeting with our committee.

The committee decided that before taking the question up with the crane manufacturers they would wait for some definite information from the motor manufacturers.

Respectfully submitted,

H. C. Meloy, N. Y. C. R. R., chairman.
C. J. Causland, Penn. R. R.
J. E. Gardner, C. B. & Q. R. R.
A. J. Farrelly, C. & N. W. R. R.
P. L. Blattey, Arnold Co., Chicago.
T. V. Buckwalter, Penn. R. R.

Data and Information

Your committee has held two meetings and revised the list of questions submitted to railroads last year. In addition to continuing the statistics as to electric car lighting, shop lighting and motor equipment, your committee will, this year, request information on welding outfits, lifting magnets, magnetic trucks and transformer equipment.

These information blanks will be sent to the various railroad officials at once, so that plenty of time may be had in furnishing information to the association before time of our annual convention.

Respectfully submitted,

Edward Wray,
Railway Electrical Engineer, chairman.
B. F. Bilsland, General Electric Co.
C. J. Causland, Pennsylvania R. R.
G. W. Cravens, C. & C. Electric Mfg. Co.
J. E. Gardner, C. B. & Q. R. R.
E. W. Jansen, Illinois Central Ry.
J. R. Sloan, Pennsylvania R. R.

Train Lighting Equipment and Practices

The members of your committee having held two meetings, the first in New York, the second in Chicago at which representatives of all the manufacturers of axle lighting equipment were present, and the third meeting at Baltimore. The first and last meetings, as members of the M. C. B. Committee and the second as a joint meeting of the A. R. E. E. and M. C. B. associations.

As a result of these meetings, the members have taken the liberty to revise certain recommended practices, and to make other recommendations in order to bring them up-to-date.

By—

(a) Eliminating features not essential to interchangeability.

(b) Additional matter made necessary on account of progress in the art and interchangeability.

(c) Re-grouping under suitable headings all features pertaining to the same subject.

(d) Re-wording of sections heretofore more or less ambiguous.

(e) Otherwise rearranging subject matter to conform to the progress of the art.

In view of the fact that the report of the members is also a committee report to the M. C. B. association it would not be becoming for our association, at this time to publish the same in detail, previous to its presentation to M. C. B. association.

In a general way the committee would, however, call to your attention certain changes, which we think it would be advisable to discuss at this time.

1. Voltage

The committee recommends the elimination of 60 volt axle equipment as only two percent of cars at present equipped with individual axle generators are equipped with sixty volt systems. Also a decreasing tendency in the use of equipment of this voltage for application to individual cars, it is felt that further use of this voltage should no longer be recommended.

2. Descriptive Notice

The descriptive notice as at present recommended does not give full information.

3. Clearances

The minimum limits of belt clearance have been more clearly given, where belt passes over or under end sill, brake beam, and car body.

4. Generator Suspension

Wording changed and the feature of safety chains or its equivalent added, to provide for greater safety.

5. Generator Mounting

Re-worded to provide for body suspended generators.

6. Axle Pulley and Bushing

Re-grouping of subject matter, no changes in dimensions.

7 and 8. Armature Pulley, and Armature Pulley Seat

Re-grouping of subject matter and the addition of pulleys, for generators having shafts less than one and one half inches in diameter, due to development of light weight body suspended generators.

9. Size of Ball Bearings

No change.

10. Battery Boxes, Dimensions of

No changes, but re-worded to clarify meaning.

11 Ventilation

Present adopted recommendation does not provide for suitable ventilation, revised recommendation gives definite area for inlet and outlet.

12. Battery Trays, Dimensions of

Eliminated certain details of battery construction not essential to interchangeability, and provides such dimensions as are necessary for interchangeability.

13. Batteries, Connectors for

Wording re-arranged and certain changes made to clarify meaning and promote interchangeability

14. Charging Receptacles

Recommendations changed to eliminate obsolete types and bring design up-to-date.

15. Fuses

Changed to clarify meaning and provide for interchangeability and cover all types of fuses and fuse blocks, in general use.

16. Wiring

Re-grouping of present recommendations.

17. Writing—Train Lines and Connectors

Re-grouping of present recommendations, and wording changed to clarify meaning.

18. Generator Leads

Recommendations changed to permit use of a superior and less expensive construction of equal safety for use where such would seem to be desirable, as on body suspended generators.

19. Switchboards

Subjects re-grouped, and wording changed to clear up ambiguity.

20. Type of Fuses

Subject matter re-grouped and minor changes made to cover all fuses in general use.

21. Installations of Conduit and Wire

The members of our committee, as members of the M. C. B. committee have prepared a set of rules covering above subject, which provides for the installation of **Conduit, Fuses, Junction Boxes** and **Wiring,** as the 1915 revised rules of the National Board of Underwriters, as applying to car wiring, were drawn primarily to cover wiring of cars which are electrically propelled, and are therefore not applicable to electrically lighted cars in steam service. The rules submitted to the M. C. B. provided all the safeguards heretofore required by the National Board of Fire Underwriters.

22. Lamps

No change in present standard, but recommended that the S-17 and S-19 lamps be also made standard.

23. Axles

No change in axles heretofore approved as, "Recommended Practice," but dimensions added to conform to M. C. B. standard axles.

The committee feels that paragraph No. 12 of the 1915 M. C. B. Proceedings be eliminated; this paragraph calls for an emergency fuse close connected to the generator. The committee respectfully presents this as a progress report, and will endeavor at our annual meeting to present our recommendations in detail, for letter ballot.

Respectfully submitted.

D. J. Cartwright, L. V. R. R., Chairman
J. H. Davis, B. & O. R. R.
E. W. Jansen, I. C. R. R.
C. H. Quinn, N. & W. R. R.
H. C. Meloy, N. Y. C. R. R.
J. R. Sloan, Penn. R. R.
E. Wanamaker, C. R. I. & P. R. R.
C. R. Gilman, C. M. & St. P. R. R.
E. Lunn, Pullman Co.

Belt Tests on the Canadian Pacific

E. S. M. Macnab

The general adoption of the body-hung axle light generator means that the question of belt life obtained with this type of machine is most important. For this reason, the accompanying table which gives the results and mileages obtained under service conditions with two types of body-hung generators on the Canadian Pacific should be of interest. It will be noticed that the first part of the table gives the results obtained from belts where the belt tension is due to the weight of the generator only, the second part shows the mileages obtained from belts used with machines equipped with spring tension devices.

Not only were various makes of belts used in these tests but, in many cases, the belts were of special construction as indicated in the second column of the table, the object being to endeavor to determine the type of construction best suited to the conditions met with on the Canadian Pacific. Following are detailed descriptions of the various belts used.

Dulcimer.—A 4-in. canvas belt impregnated with balata gum, upon which 1 in. by ⅛ in. by 4 in. leather strips have been riveted with three ¼-in. copper rivets per strip. The strips were placed ¼ in. apart. In applying the strip hollow expanded rivets were used, the riveting being done on the pulley side of the strip. A sketch of this type of belt is shown in Fig. 1.

Balata Cotton Stitched.—A 4-in. 4-ply balata belt in which has been threaded four rows of cotton thread. The stitches on the pulley side of the belt were about ⅜-in. long and on the outside of the belt ¼-in. long. The cotton twine used was woven cotton 1/16-in. in diameter.

Steel Stitched Belt.—This belt is the same as the cotton stitched except that the stitches are made up of two rows of steel staples pitched ½ in, apart, each row ½ in. from the edge of the belt. The stitching is composed of steel staples 1/16 in. by 1/16 in. clinched over into the belt.

Copper Stitched Belt.—The construction of this belt is the same as the cotton stitched belt except that three rows of copper stitching are used, the stitching being composed of copper staples applied similarly to the steel stitching.

Balata Two Rows of Copper Stitching.—Same construction as the three row type of belt described above.

Balata Riveted.—Same type of belt as the cotton stitched with two rows of ⅛-in. rivets located ½ in. from each side with an 8-in. pitch. The riveting was done on the outside of the belt.

Little difference in life was found between the copper and steel stitched belts but both were more serviceable than the riveted type as the stitching prevents the several plys of the belt coming apart. The Dulcimer type gives better results in winter as the leather strips tend to keep the axle pulley free of ice but its general use is not practical due to its high initial cost. All balata belts were tested on equipment where a slipping belt is used to control the output of the generator. The average belt life obtained on the Canadian Pacific during 1915 was 49,140 miles, the maximum being 97,567 in October with a minimum of 17,621 miles in January. The number of cars in operation was 390.

Results of Belt Tests on Body Suspended Axle Generators.

Output Controlled by Slipping Belt Method.

Make	Type of Belt	Belt Mileage	Remarks
A	Steel stitched	84,376	Lost
B	Copper stitched	84,376	Lost
A	Steel stitched	102,150	Removed
B	Copper stitched	102,150	Removed
C	Riveted	103,208	Removed
A	Steel stitched	103,208	Removed
A	Steel stitched	96,553	Lost
C	Riveted	96,553	Lost
C	Riveted	101,608	Removed
A	Steel stitched	101,608	Removed
B	Copper stitched	....	Car transferred to trains 13 and 14
B	Copper stitched	21,728	Lost
C	Riveted	21,728	Lost
D	Copper stitched	43,956	Removed
D	Copper stitched	23,176	Belt removed, cracked
D	Copper stitched	11,588	Cracked
E	Riveted	74,228	Removed, worn
E	Riveted	60,380	Removed
C 2	Dulcimer	65,131	Belt removed, badly worn
C 2	Dulcimer	53,354	Worn
A 2	Balata, two rows copper stitching	39,760	Lost
A 3	Three rows steel stitching	63,144	Lost
A 4	Riveted	38,150	Lost
A 5	Two rows of hemp stitching	78,960	Lost
A 6	No rivets or stitching	71,730	Lost
A 7	Four rows of hemp stitching	73,960	Lost

Output Controlled by Field Control.

Make	Type of Belt	Belt Mileage	Remarks
G	5-in. 4-ply rubber	37,250	Worn out
G	5-in. 4-ply rubber	44,380	Lost
G	5-in. 4-ply rubber	60,402	Worn out
G	5-in. 4-ply rubber	63,076	Worn out
G	5-in. 4-ply rubber	69,115	Worn out
G 2	4-in. 4-ply Dulcimer	79,747	Worn out (small 3 kw. generator)

Application of Anti-Friction Bearings

On Electric Tractors and Industrial Trucks in the Service of the Pennsylvania

T. V. Buckwalter

The application of ball and roller bearings for machinery used in railroad service has been given considerable thought as the demand for more efficient service has increased, and it is thought that some information regarding the application of ball and roller bearings to machines that have seen several years of useful service would be particularly interesting at this time.

The most interesting application involving the greater weight and driving power is that of an electric tractor which has given continuous service since January, 1913, without any failures attributed to the bearings or mechanism supported by the bearings.

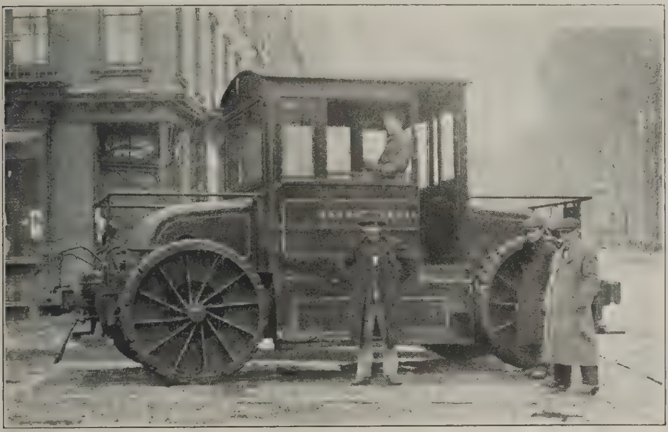

Fig. 1. The Electric Tractor.

General Description of Electric Tractor*

A brief description of the electric tractor is thought advisable in order to illustrate to better advantage the application of the bearings particularly in view of the fact that all driving mechanism on the tractor from the armatures to the road wheels are carried on ball bearings.

The design of the tractor is a composite of motor truck and electric locomotive construction, the general layout partaking of the nature of a locomotive and the driving mechanism incorporating features developed in connection with electric industrial trucks. The cab is located in the center of the machine and the steering wheel in the center of the cab. This construction provides the simplest means of instantly operating in either direction from either side of the controlling mechanism. Driving, steering and braking is accomplished on all four wheels and provides a maximum draw bar and the greatest flexibility in handling a large machine in congested districts.

The driving apparatus is divided into two units which are in duplicate, one unit driving each pair of wheels at the respective ends. The driving mechanism of each unit consists of a motor flexibly connected to a driving pinion which meshes with a countershaft gear, supported by the differential. The differential is connected by countershafts to universal pinions meshing directly with the driving gears on the wheels. The universal pinions provide a simple mechanism for driving the steering wheels, the application of four wheel steering requiring steering knuckles on each wheel.

The tire equipment consists of 60 in. by 6 in. dual blocks on each wheel, the steering wheel is 42 in. in diameter, while other parts of the driving and steering mechanism are constructed in this proportion. The machine is provided with standard M. C. B automatic couplers at each end, these couplers being connected to the center sills of the tractor by means of radial draft gear.

The brakes are connected to each of the four wheels and are operated by hand through the medium of a hand wheel and suitable gearing, and also automatically by air, the compressed air being furnished by a standard railway type motor driven air compressor. The air brake equipment is designed to operate the brakes on the tractor simultaneously with the brakes on the cars it is handling. The compressor equipment is sufficient for a total of six cars.

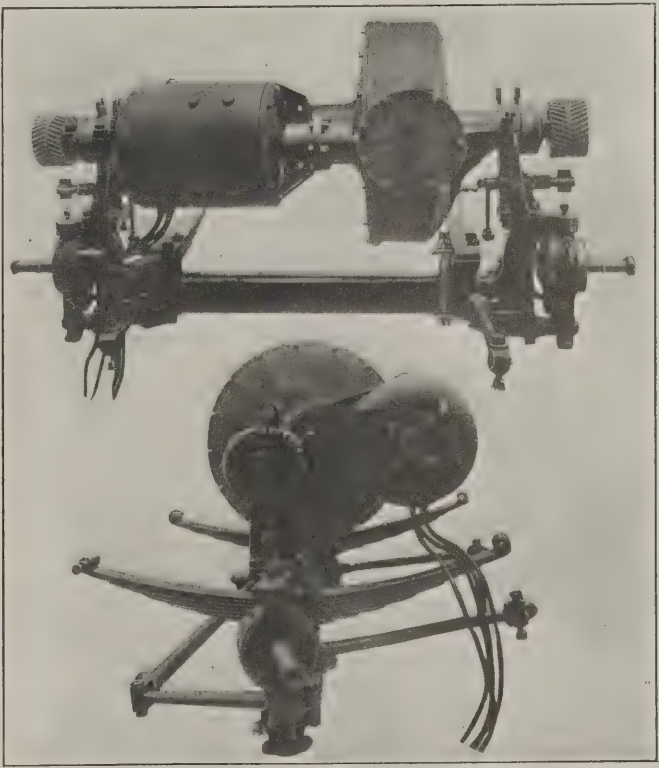

Fig. 2. Electric Tractor—Driving Wheel.

The source of energy is an Edison battery consisting of 180 cells of the type A-12, this battery being divided

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*A complete description of this tractor appeared in the *Railway Electrical Engineer* for November, 1913.

into two units of 90 cells each which are used interchangeably. A battery of 90 cells is charged at night and discharged the next morning. During the noon hour the exhausted battery is removed by means of special transfer mechanism and the freshly charged battery inserted. This battery furnishes energy for the afternoon's work and is charged on the machine at night without removal.

A standard General Electric controller is mounted on one side of the cab, but the control mechanism is provided in duplicate on each side of the cab and is adapted for operation in either direction from either side. The wiring is simplified and electric complications avoided by the operation of a single controller from either side of the cab and is accomplished by simple mechanical mechanism.

The control mechanism in addition to the controller consists of an air compressor governor, switch, volt and ammeter, speedometer, including mileage indicator, charging plug and double throw switches, ampere hour meter, air brake valves located on each side of the cab and switches for controlling the lights.

Application of Ball Bearings

The electric tractor is equipped with a complete application of ball bearings in the driving mechanism from the armatures to the road wheels, the ball bearings being selected for the following reasons:

> The space available for the battery is subject to considerable restriction, and to obtain the maximum amount of work per charge, ball bearings were used as their use almost entirely eliminates friction from the bearings and confines the frictional losses to the commutator, gears and tires.
>
> The ball bearings require a very slight amount of lubricant and by providing considerable space for the lubricant, the renewal can be done at intervals of only four times a year. The term "renewal" is used advisedly, as the design provides for the addition of new lubricant to one side of the bearing which forces out the old lubricant through suitable annular passages. By this method the necessity of complete renewal is avoided as the application of the new grease at these infrequent intervals forces out the old grease together with the dirt it has accumulated.
>
> The third reason for the use of ball bearings is that the wear is practically negligible, while a certain amount of wear occurs, it is a very slight amount as compared with plain bearings, and on account of this reason the mounting of the gears and shafts when once made correctly remains fixed. This theory is borne out by the fact that the countershaft on the tractor has been in continuous service for three and a half years, during which time the alinement has been maintained as originally set and the wear of this gear is practically negligible.

The data regarding the application of ball bearings will be described in detail:

Motor Bearings

Ball bearings are used on the motor with the object of attaining a small air gap and constant relation between the armatures and field, and between the brushes and commutator together with the minimum of attention and economy of space which results from the use of the bearings. The weight of each motor is 600 lb., and their rating is 85 volts, 60 amperes at 900 R.P.M.

The motor is liberally designed and is worked at frequent intervals daily developing a torque 6 to 10 times the normal rating.

The ball sizes on the pinion end is No. 312, and on the commutator end No. 310. The capacity of the No. 312 bearing at 900 R.P.M. is 1,950 lb. and of the No. 310 at 900 R.P.M., 1,400 lb. The design provides for no additional loads on the bearings except the weight of the armature, which would be somewhat less than 200 lb. on each bearing. This is due to the fact that the armature is connected by means of a flexible coupling to a pinion shaft which takes all the gear strains.

Motor Pinion Bearings

The motor pinions are made integral with the motor pinion shaft and are supported on two ball bearings No. 311, the capacity of which at 900 R.P.M. is 1,660 lb., and the load due to the gear reaction at this speed is 140 lb. each. Due to the steep torque of this motor, the load on the gear teeth increases rapidly with the reduction in speed, and at 330 R.P.M. the load due to the gear reduction is approximately 1,010 lb. each. The load on these bearings at which the tractor slips on dry pavement is approximately 3,160 lb.

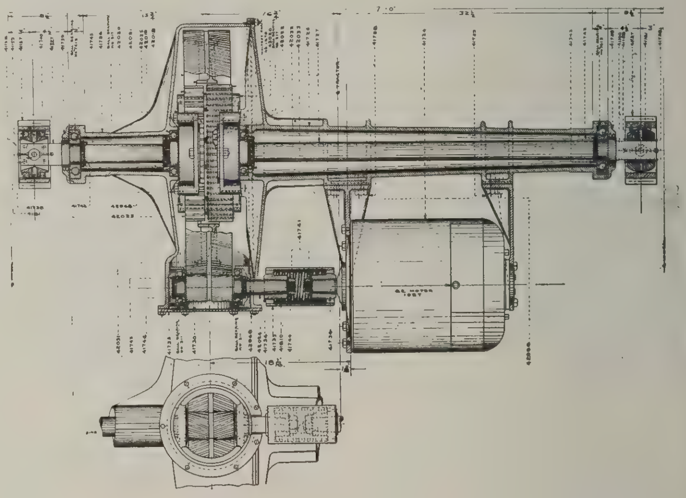


Fig. 3. Electric Tractor—Countershaft Assembly, Showing Motor Pinion Bearings, Differential Bearings and Countershaft Bearings.

From this data it will be apparent that the motor pinion bearings, of which there are four on a machine, are worked daily at variable loads amounting to one-half the rating of the bearing for constant load, whereas the load imposed on this bearing due to starting heavy drafts of cars at times reaches a point 50 per cent in excess of the normal constant load of the bearing.

The mounting of the motor pinion bearings, differential bearings and countershaft bearings is shown on the attached photograph of drawing entitled Countershaft Assembly.

Differential Bearing

The differential bearing supports the countershaft gear and the differential gear, the countershaft gear being bolted to a spider supported by the differential gear. The differential gear is supported by means of extended hubs on ball bearings No. 217, the outer race of which is supported directly in the countershaft housing. The ratio between the motor pinion and the countershaft gear is

20 to 185, giving a reduction of 9¼ to 1. The capacity of the No. 217 bearing at 200 R.P.M. is 3,080 lb. each, while the load with the tractor running light and the countershaft gearing running at 100 R.P.M. is 640 lb. The load on these bearings with the tractor pulling a heavy draft of cars and developing 8,000 lb. draw bar is 1,250 lb. each, or approximately 40 per cent of the constant load capacity of the bearings. The load imposed on these bearings when slipping on dry pavement is approximately 3,300 lb. each, or slightly above the constant load of the bearing. The load on the differential bearing is subject to wide fluctuations, due to the fact that the weight of the gear and differential is added to the gear reduction in one direction and subtracted in the opposite direction. The above figures are a maximum when the two loads are cumulative.

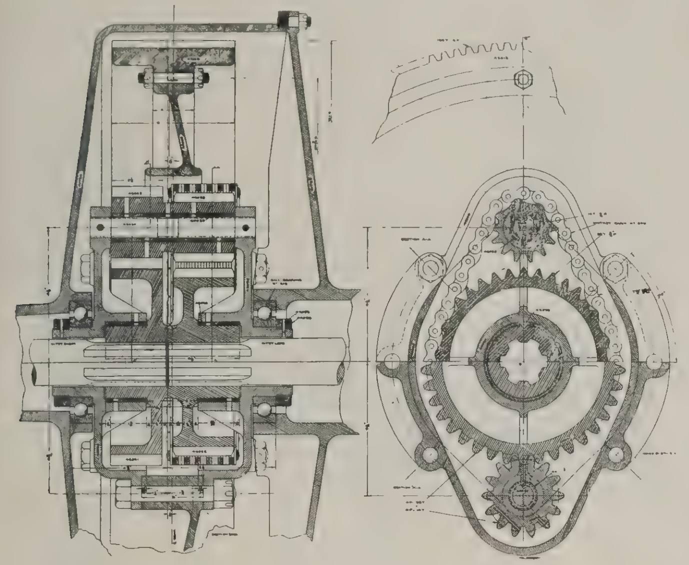


Fig. 4. Electric Tractor—Differential and Bearing Mounting.

Countershaft Bearing

The countershaft bearings are subject to wide variation in load on account of the fact that they are mounted on the three-quarters floating principle, this term being used in automobile parlance to describe an axle in which the inner end is free to float on a separately supported differential, and the outer ends are supported on bearings which take the radial load in addition to the thrust reaction. The size of the countershaft bearing is No. 413 and the capacity of each bearing at 200 R.P.M. is 4,950 lb., and the load with the tractor running light and the countershaft rotating at 100 R.P.M. is 560 lb. each, and the load with the machine developing 8,000 lb. draw bar at 35 R.P.M. is 5,150 lb., or slightly in excess of the normal constant load capacity at 200 R.P.M. The load imposed on this bearing when the tractor is working up to slipping point on dry pavement is 12,900 lb., which of course occurs at very low speeds.

In addition to the above loads, each of these bearings takes a thrust load of 1,750 lb. due to reaction of the driving gear when turning corners when the tractor is working at a draw bar of 8,000 lb. on a minimum radius bend. It should be stated that this condition occurs at rare intervals for the reason that the machine will turn in a 25-foot radius, whereas the minimum radius over which cars are pulled is about 50 ft.

Main Wheel Bearings

The main wheel bearings consist of annular ball bearings No. 319 on the inside, and bearing No. 410 on the outside, each of which is arranged to take radial load only. The construction provides an S.K.F. thrust bearing No. 1712 which takes the thrust load in both directions.

The total weight of the machine is roughly 30,000 lb. The weight of the four wheels with tires, gears, rims, etc., is approximately 8,000 lb., leaving 22,000 lb. weight carried by the bearings or 5,500 lb. to each wheel. Of this load 3,050 lb. are supported on the inner bearing and 2,450 lb. on the outer bearing.

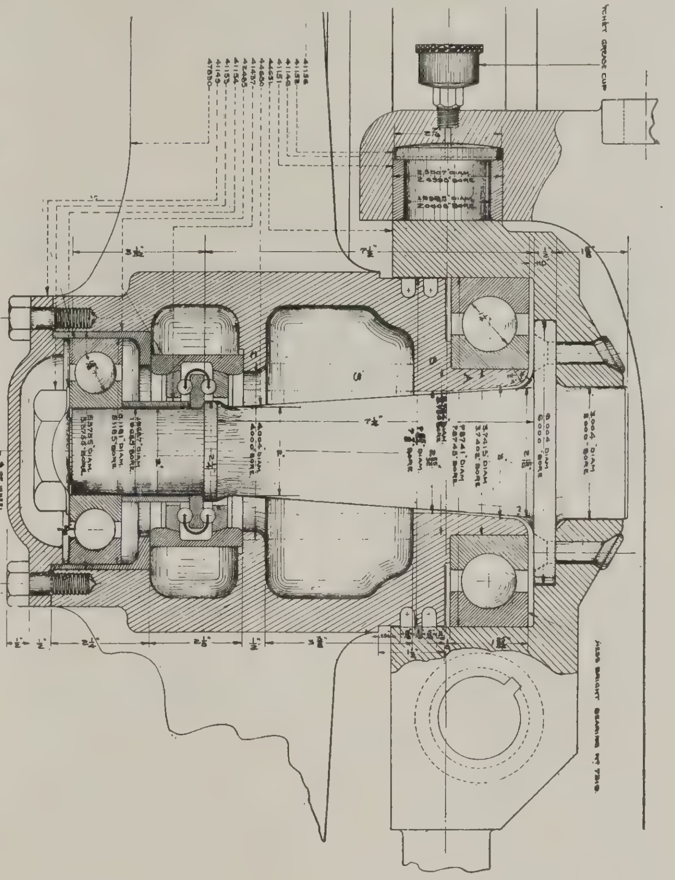


Fig. 5. Electric Tractor—Hub Section, Showing Annular Ball Bearings Taking Radial Load and Two Direction Thrust Bearing for Thrust Load.

The wheel bearings in addition are required to take a component due to gear reaction, which at 8,000 lb. draw bar amounts to 4,560 lb. of which 8/9 is assumed by the inner bearing. This results in a total load in consideration of the weight on the inner bearing of 5,560 lb., whereas the capacity of the bearing at 200 R.P.M. is 6,820 lb.

The component due to gear thrust at 8,000 lb. draw bar on the outer bearing is 570 lb., which together with the weight on the outer bearing is 2,450 lb. results in a total load of 2,530 lb. on the outer bearing which compares with the rated capacity of this bearing at 200 R.P.M. of 3,080 lb., so that this bearing is working at about 5/6 of its normal capacity.

The capacity of the thrust bearing is approximately 7,000 lb., which compares with a total weight on each wheel of about 7,500 lb. The static stress on the thrust bearing would not be more than about one-quarter of this weight, but the stress due to shock might under certain conditions equal the weight.

The total gear ratio is approximately 38 to 1.

Results of Operation of Ball Bearings on Electric Tractor

The ball bearings as above described have been in service on this machine for three and a half years, and during this time there has been no failure due to the bearings and no failures of the parts supported by the bearings. June 5, 1916, completed three years since the machine has lost any time on account of mechanical failure. The bearings have been examined occasionally and have not disclosed any wear that can be noticed without a complete dissembly of the bearings, and it is apparent that the service has not reached a point where the life of the bearings can be approximated.

The volume of work done by the tractor is represented by a total of 30,852 cars placed, which if connected would extend a total distance of 234 miles.

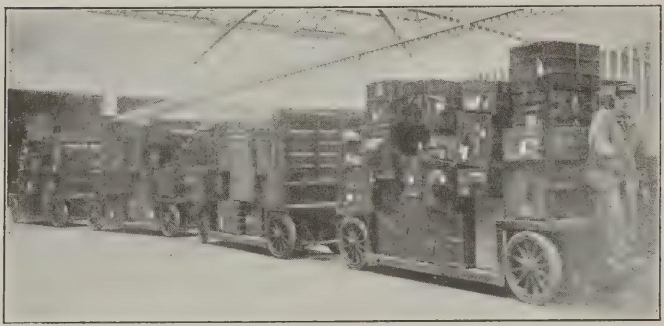


Fig. 6. Drop Frame Truck With Loaded Trailers.

The distance operated in the 34 months' service to May 1, 1916, is 12,068 miles, which represents an equivalent distance if traveled by an automobile of 120,000 miles.

General Description of Electric Industrial Trucks

The industrial trucks as developed by the Pennsylvania Railroad represent the first machines used by the railroad in which all the driving mechanism is carried on ball or roller bearings, and it is fair to state that much of the success of these trucks, of which there are over 200 in the Pennsylvania Railroad service, is due to the decision to use ball and roller bearings on all driving mechanism and the care with which the bearing sizes were selected.

The industrial trucks are all of the general capacity of 4,000 lb. and the weight ranges from 2,200 to 3,000 lb., depending upon the general design of the machine. The smaller machines for freight and shop service weigh 2,200 to 2,400 lb., and the larger machines with 13 ft. 4 in. drop frames and cross rail for handling mounted car wheels weigh about 3,000 lb.

The feature of double end control is provided on all the industrial trucks, except the small warehouse trucks for use in freight service, which are single end control due to the fact that the rear end of the truck is only 10 in. in height to facilitate transfer of loading.

The data which follows on the loads carried by the ball and roller bearings has been calculated on the basis of the drop frame truck weighing 3,000 lb., but the motor, differential and countershaft bearing data is practically identical on all classes of trucks, whereas the load on the wheels varies somewhat with the weight of the truck, but when consideration is taken of the fact that the capacity of 4,000 lb. is common to all the trucks, it is evident that the variation in weight on the wheel bearings is practically negligible.

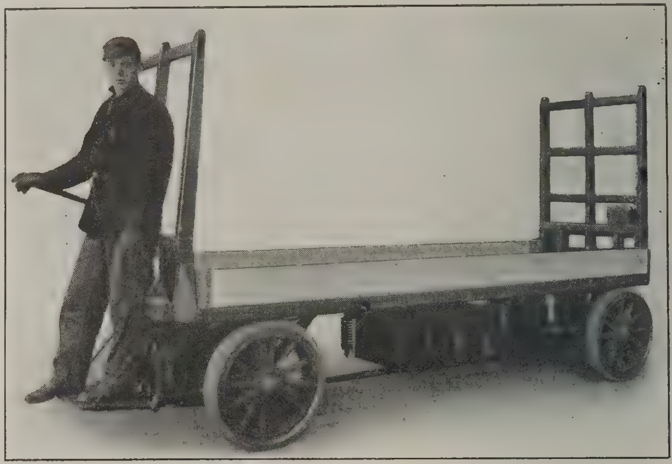


Fig. 7. Straight Frame Truck.

The industrial trucks differ from the electric tractor in that driving is accomplished on two wheels only for the reason that sufficient traction for the truck and train of trailers is available with two wheel drive and the complication of four wheel drive is therefore unnecessary.

Braking is also accomplished on two wheels and to simplify the mechanism braking is done on the two wheels on the opposite end from the driving wheels. Steering, however, is done on all four wheels as this reduces by one-half the turning radius of the truck and makes the front and rear end track exactly, which is not the case with two wheel steering trucks and increases to a maximum the size of the trucks readily handled in ordinary shop and baggage runways. The use of four wheel steer also makes the operation of double end control entirely safe, as the manipulation of the control levers and the response of the steering wheels is therefore identical whether operated from either end of the truck.

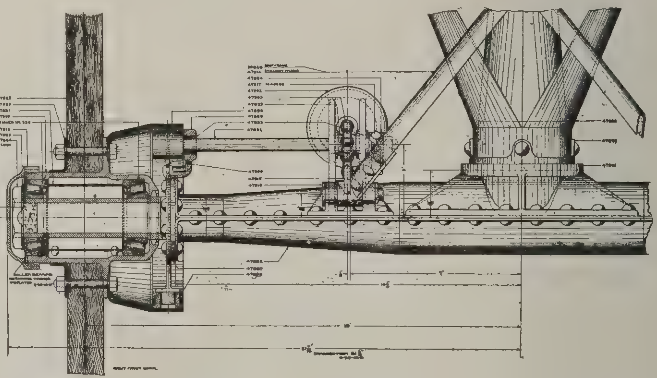


Fig. 8. Steel Hand Baggage Truck—Front Axle Section Showing Application of Timken Bearings.

The attached photographs show drop frame trucks loaded, with trailers, and drop frame shop truck for handling mounted wheels and straight frame baggage trucks.

The baggage trucks are equipped with wheels having tire equipment 27 in. by 3½ in. A.R.E.E. standard. The warehouse trucks are equipped with wheels 20 in. or 22 in. by 3½ in. in front and 10 in. dual rear wheels. The gear ratio on trucks having 27-in. wheels is approximately 27 to 1, and correspondingly less on trucks having smaller driving wheels.

The standard battery equipment is 21 A-6 Edison cells, or 12-15 pasted plate lead cells. A standard controller provides three speeds in either direction. The battery is made removable and on the large installations at New York, Philadelphia and Pittsburgh passenger stations the trucks are in service twenty-four hours a day. About 10 minutes per day is utilized for truck inspection and change of batteries. The batteries in small installations are charged at night without removal.

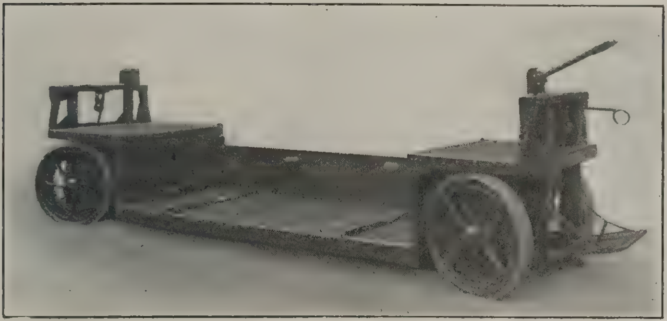


Fig. 9. Drop Frame Shop Truck With Cross Rails.

The reasons for the selection of ball and roller bearings for electric tractor, as outlined under the description of the electric tractor, are applicable to industrial trucks but with increased force for the reason that space is more restricted on industrial trucks and the attention they receive is more likely to be stinted than the tractor.

Motor Bearings

The standard motor has a rating of 24 volts, 60 amperes, 1,400 R.P.M. and weighs about 140 lb. The load on the motor varies within wide limits, while an ampere draw of from 40 to 50 is sufficient to propel the truck with light load on good pavement under ordinary conditions, heavy loads on steep grades ranging to 20 per cent. require an ampere draw of 100 to 150 amperes, while to start the load on steep grades might require surges of possibly 250 amperes. The calculations which follow are made at loads of 60 amperes, 150 amperes and slipping point with load is estimated 2½ times the torque at 150 amperes.

The size of the motor bearing on the pinion end is No. 306, of which one is required on the truck. The capacity of the bearing at 1,400 R.P.M. is 500 lb. and the load at 1,400 R.P.M. and drawing 60 amperes is 120 lb. The capacity at 800 R.P.M. is 625 lb., and the load at this speed drawing 150 amperes is 330 lb., or a little more than one-half the normal constant rating of the bearing. The slipping load is estimated at 750 lb.

The size of the bearings on the commutator end is No. 305. The capacity at 1,400 R.P.M. is 365 lb. and at 800 R.P.M. is 485 lb. The load on this bearing is practically constant at about one-half the armature weight regardless of the work the motor is doing and seldom exceeds 50 lb.

Differential Bearings

The differential is supported on two bearings No. 210, the bearings being mounted in the countershaft housing and supporting the differential by means of extended hubs on the differential housing. The drive to the countershafts is by means of the three-quarter floating arrangement. The capacity of these bearings at 200 R.P.M. is 990 lb., and the load at 210 R.P.M. with the motor drawing 60 amperes is approximately 60 lb. each, and at 110 R.P.M., drawing 150 amperes the load is approximately 170 lb. each and the slipping load approximates 375 lb. This bearing is therefore rather lightly loaded and is due to the fact that the selection of the bearing size is controlled largely by mounting conditions.

Countershaft Bearings

The ends of the countershaft are carried on bearings No. 308, one bearing supporting each end of the divided countershaft. The loads on this bearing are similar to bearing No. 413, described under the electric tractor, and are subject to wide variations.

The load rating of the No. 308 bearing at 200 R.P.M. is 1,430 lb., and the radial load at 210 R.P.M. with the motor drawing 60 amperes is 130 lb., while the radial load at 110 R.P.M. and drawing 150 amperes is 490 lb. The slipping load is estimated at 1,270 lb.

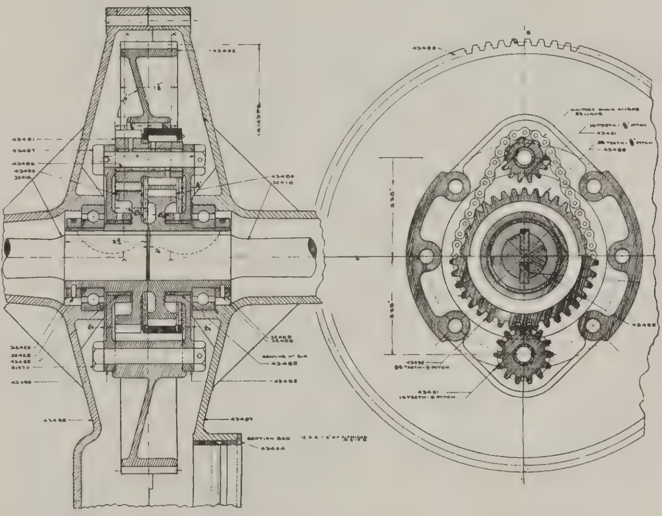


Fig. 10. Electric Baggage Truck—Section of Differential Showing Ball Bearing Mounting.

In addition to the above radial loads, these bearings take a thrust load due to the gear reaction in rounding curves, which under extreme conditions amount to 40 lb. thrust load at 210 R.P.M., 160 lb. thrust at 110 R.P.M. and 400 lb. estimated in slipping. The capacity of annular bearing for taking thrust is about one-quarter the capacity for taking radial load and these latter figures would therefore have their equivalent in radial load at four times the above values. This would make the equivalent radial load due to thrust at 110 R.P.M. equal to 640 lb. each., together with the radial load at a speed 110 R.P.M. of 490 lb. would make the total load 1,130 lb., or approximately 80 per cent of the normal loading capacity of the bearings.

This data should be particularly interesting in view of the fact that there have been no failures, except one which was due to the absence of lubricant.

Main Wheel Bearings

The wheels of the industrial trucks are carried on Timkin bearings. The selection of the Timkin bearing being due to the fact that they are somewhat smaller than the ball bearings having similar capacity, and the thrust to which the road wheels are subjected can be provided for in a simpler manner with the Timkin bearings, which are of the taper variety than with the ball bearings. The Timkin bearing number of the inner bearing is 395, and the outer bearing 335.

The weight of the truck selected for computation is 3,000 lb. and on this truck the weight of the wheels, rims, tires, brake bands and gears is 440 lb., leaving a net weight on the bearings of 2,560 lb. due to the empty truck. The load capacity is 4,000 lb. evenly distributed, making a total weight on the bearings with load of 6,560 lb., or 1,640 lb. to each wheel. The weight distribution on these bearings is approximately 42 per cent on the inner bearing and 58 per cent on the outer bearing, which makes the weight on the inner bearing 680 lb. and on the outer bearing 960 lb. These bearings are also subject to considerable load due to the reaction of the driving gears, this load amounting on each wheel to 95 lb. at 55 R.P.M. running light and 380 lb. at 30 R.P.M. with the motor drawing 150 amperes on heavy grade. This thrust approaches 950 lb. before the wheels slip with load on dry pavement.

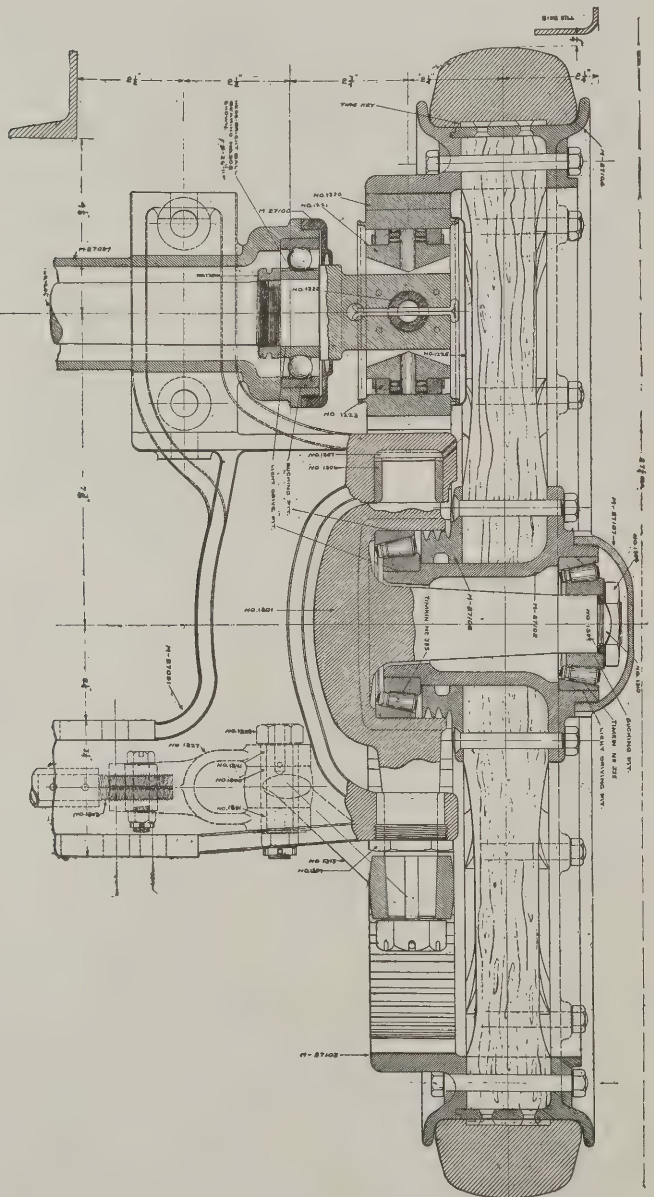


Fig. 11. Electric Baggage Truck—Section Through Driving Wheel Showing Application of Timken Bearings and Ball Bearings Supporting Countershaft.

The proportional gear thrust on the inner and outer bearings at 30 R.P.M. and 150 amperes is 350 lb. on the inner bearing and 30 lb. on the outer, and inasmuch as this gear thrust is in a direction 90° from the load which is in a vertical direction, the resultant bearing loads at 30 R.P.M. and 150 amperes is 760 lb. for the inner bearing and 960 lb. for the outer bearing, which compares with the capacity of the number 395 bearing used as the inner bearing of 830 lb. and 625 lb. for the outer bearing number 335.

From the above it will be noted that the outer bearing works under full load and under the worst conditions at about 50 per cent above its normal rating for steady loads, whereas the inner bearing is working about 85 per cent of the similar capacity, but in addition to the above stress, the inner bearing takes the thrust stress due to curving, which would increase its total load to a proportional amount with the outer bearing.

Bearing Failures

Industrial trucks were first placed in service on the Pennsylvania Railroad in 1907, and commencing in 1909 they were used in considerable numbers, so that results of operation can be estimated on the basis of six years' service, and when consideration is given to the fact that most of the 216 trucks in service are used twenty-four hours per day and seven days a week, the results of operation with ball bearings should be of considerable interest. While there have been a number of failures, it is thought that consideration should be given to the facts in connection with bearing failures. There have been several failures of the motor bearings, principally at the commutator end and inasmuch as the bearing at the commutator end carries very little load, it has generally been found to be due to the loosening of the nut which clamps the inner race to the shaft. The experience of this company indicates that the inner race of a ball bearing cannot be secured too firmly.

There is one failure on record of a differential bearing, which was due to too loose fit of the inner races on the extended sleeve of the differential so that the resultant motion under load wore away the clamping action of the nut on the extended hub which allowed the bearing to set up a chattering action in service. This action, when allowed to develop, wears a series of holes in the races of the bearing.

There have been about six failures of wheel bearings of the Timkin type, all of which are due to shocks incident to baggage trucks dropping from station platforms to the railway tracks below. There are no records of any of these bearings failing from service.

In the nine years that the ball and roller bearings have been in service on industrial trucks, there has been no occasion to change the size or type of any of the bearings and no such changes are contemplated at present.

Method of Cost Keeping for Railroad Shop Power

E. Wanamaker*

The accompanying sheet No. 1—Skeleton Form for Costs and Load,—together with sheet No. 2—Distribution of Costs—outlines a method that will permit a cost comparison on the total power cost figure only, or the costs may be run down and subdivided to any degree of fineness desired, by each individual company. The relative cost per unit of shop output being decided by the monthly production of shop.

Skeleton Form for Costs and Load

Itemized cost of power	Daily cost	Cost per 1000 lb. of steam	Cost in equivalent K. W. H.
Labor	......	......	......
Oil—Quantities, kind and costs	......	......	......
Waste—Quantities	......	......	......
Maintenance materials	......	......	......
Packing	......	......	......
Machinists' and boiler makers' labor	......	......	......
Coal—Price per ton, including freight	......	......	......
Water—Quantity price per 1,000 gal	......	......	......
Handling material by store dept. (at so much per $1.00)	......	......	......
Shops, pro rata	......	......	......
Interest, depreciation, taxes and insurance on total power plant inv	......	......	......
Total cost per day	......	......	......
Total cost per month	......	......	......
Total cost per year	......	......	......

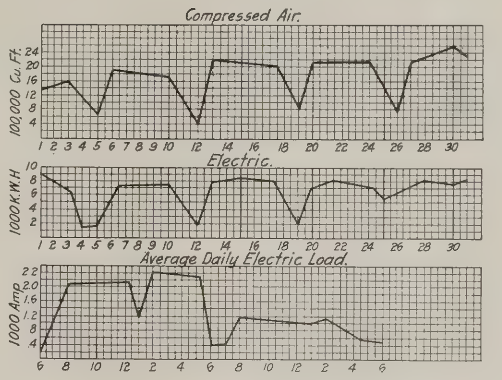
Shop output for the current month—

Engines	....
Cars	....
Shop orders	....
Percentage shop orders to total work done	....

Shops Labor

	Machinists	Boiler M.	Smiths	Carp'n'r	Electr'n Crane man	Pipe fitter	Tinsmiths	Painters	Clerks, etc.	Helpers	Laborers	Not listed elsewhere	Total
Office supt. of shops	..	..	..	..	..	..	..	..	..	..	..	..	..
Office asst. supt. of shops	..	..	..	..	..	..	..	..	..	..	..	..	..
Machine shop	..	..	..	..	..	..	..	..	..	..	..	..	..
Tool room	..	..	..	..	..	..	..	..	..	..	..	..	..
Rod and link	..	..	..	..	..	..	..	..	..	..	..	..	..
Air brake and injector	..	..	..	..	..	..	..	..	..	..	..	..	..
Steam pipe, driver brake, grates	..	..	..	..	..	..	..	..	..	..	..	..	..
Locomotive dept.	..	..	..	..	..	..	..	..	..	..	..	..	..
Stripping and eng. truck	..	..	..	..	..	..	..	..	..	..	..	..	..
Scale	..	..	..	..	..	..	..	..	..	..	..	..	..
Laborers	..	..	..	..	..	..	..	..	..	..	..	..	..
Blacksmith shop	..	..	..	..	..	..	..	..	..	..	..	..	..
Boiler shop	..	..	..	..	..	..	..	..	..	..	..	..	..
Tin and pipe shop	..	..	..	..	..	..	..	..	..	..	..	..	..
Carpenter and tank	..	..	..	..	..	..	..	..	..	..	..	..	..
Paint	..	..	..	..	..	..	..	..	..	..	..	..	..
Power house	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	..	..	..	..	..	..	..	..	..	..	..	..	..
Car dept.	..	..	..	..	..	..	..	..	..	..	..	..	..
Roundhouse	..	..	..	..	..	..	..	..	..	..	..	..	..
Grand total	..	..	..	..	..	..	..	..	..	..	..	..	..
Store dept.	..	..	..	..	..	..	..	..	..	..	..	..	..

Load Curves



Complete Description of Entire Power Plant and Equipment Value Thereof

Diagrams Showing Relative Position and Size of All Shop Buildings

(1) In order to arrive at the first or primary total cost of power produced for any one day or month, it will be necessary to equip power plant with meter to measure all boiler feed water. Then using evaporation figures, the approximate total number of pounds of steam generated may be found. (A closer figure may be obtained by using steam flow meter on each boiler.) Taking weight of fuel from bills or invoices, and including all costs of production as shown on sheet 1, the cost per 1000 lb. of steam may be ascertained—also, the daily and monthly steam cost.

(2) In cases where exhaust steam is used for heating purposes, it should be ascertained by checking radiation against steam and hot water return meter, what per-

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*Electrical Engineer, Rock Island.

DISTRIBUTION OF RAILROAD SHOP POWER COST

					Percentage of Cost		
				Shop Orders	Engineers	Cars	Miscellaneous
Total cost of steam generated per month. Total cost of steam generated; average, daily, for month. Cost per 1,000 lbs. of steam generated. On basis of cost of 1,000 lbs. of steam generated deduct for total number of pounds of exhaust steam used for heating. **If energy in any form is purchased add to or insert in place of that form of energy the cost thereof.**	**Electrical Energy** Total number pounds of steam required for electrical energy during month.	Total K. W. H. generated during month with total cost thereof and cost per K. W. H.	K. W. H. Machine Shop K. W. H. Boilers and Tank Shop K. W. H. Erecting Shop K. W. H. Forge Shop K. W. H. Car Shop K. W. H. Lighting System K. W. H. Store Department K. W. H. Miscellaneous				
	Pneumatic Energy Total number pounds of steam required for pneumatic energy during month.	Total number of cu. ft. of air compressed during month and total cost thereof per 1,000 cu. ft.; also expressing the cost in equivalent K. W. H., using electrical energy transformation cost figures as a basis.	Cu. ft. or K. W. H. Machine Shop Cu. ft. or K. W. H. Boiler and Tank Shop Cu. ft. or K. W. H. Erecting Shop Cu. ft. or K. W. H. Forge Shop Cu. ft. or K. W. H. Car Shop Cu. ft. or K. W. H. Store Department Cu. ft. or K. W. H. Miscellaneous				
	Hydraulic Total number pounds of steam required for hydraulic energy during month.	Total number of gallons of water pumped during month and total cost thereof per 1,000 gal.; also expressing the cost in equivalent K. W. H., using electrical energy transformation cost figures as a basis.	Number of gallons or K. W. H. equivalent Boiler and Tank Shop				
	Water Total number pounds of steam required for shop water supply during month.	Total number of gallons of water pumped during month and total cost thereof per 1,000 gal.; also expressing the cost in equivalent K. W. H., using electrical energy transformation cost figures as a basis.	These costs may be subdivided to as fine a point as desired				
	Live Steam Total number pounds of steam required for steam hammers, testing round houses, etc., during month.	Express the cost in equivalent K. W. H., using electrical energy transformation cost figures as a basis.	Do.				
	Live Steam Heat Total number pounds of steam required for live steam heating during month.	Express the cost in equivalent K. W. H., using electrical energy transformation cost figures as a basis.	Do.				
—— **Total.**	—— Total.	—— Total. Total ——	—— Total.				

centage of the total number of pounds of steam used for power during month, is again used for heat.

To secure a total power cost, and make a charge for the steam heat, it will be necessary to deduct the cost of total number of pounds of steam used for heating from total cost of steam generated during month. Thus for example:

Total number of pounds of steam generated for month=1,000,000 lb. @20c. per 1,000 lb.=	$200.00
Total number of pounds of steam used for heating during month=500,000 lb. @20c. per 1,000 lb.=	100.00
Then	$100.00

only should be charged for the 1,000,000 lb. at the rate of 10c. per 1,000 lb.=$100.00 for 1,000,000 lb. of steam. The difference in cost of generating heating steam at a high pressure, as compared to generation at low pressure, will be compensated for by back pressure thrown on power steam, when heating system is in operation. The steam should not be charged for twice.

(3) Using cost per 1000 pounds of steam generated as a basis, and ascertaining by use of test indicators and meters, quantity of steam used to make the different forms of energy required, the cost thereof may be found in units of K. W. H., cu. ft. gallons, etc. It is also possible to reduce to and express the cost of all forms of energy in the equivalent of K. W. H., using the electrical energy conversion or transformation cost figures as a basis, meaning so many pounds of steam per K. W. H. This will facilitate ease of comparison.

(4) The cost of purchased energy in any form should be added to or inserted in place of that particular form of energy, so that it may be added to the total cost of the whole. Also, that the cost may be properly subdivided and distributed.

Maintenance of Lead Storage Batteries in Car Lighting Service

Ernest Lunn

It is the purpose of this paper to call attention in particular to three seemingly simple and unimportant things in connection with the maintenance of lead storage batteries in car lighting service, viz.:

(1) Maintenance of uniform condition of the battery cells.
(2) Remedying defective cells.
(3) Individual cell voltmeter readings taken while the battery is being discharged.

These are referred to as seemingly simple and unimportant things, for the reason that they are too often so considered by those whose duty it is to care for batteries, both in the railroad yards and in the repair shops, and it may be due to this fact that defective cells are not always remedied, even after their condition has been revealed by the simplest of the three things referred to—the taking of individual cell voltmeter readings while the battery is discharging.

Many books on the subject of storage batteries have been written, but despite this fact some of the most effective methods, especially those affecting details of maintenance, are frequently overlooked. There can be no good excuse for such negligence, since to put them into effect requires the minimum of time to carry out, involves practically no expense, and in the majority of cases produces results that would warrant going to a great deal of trouble to obtain. If for instance, individual cell voltmeter readings are taken when a battery is being discharged, the readings will usually show, almost at the very beginning of the discharge, whether any cells have less capacity than others in the same battery. Such readings taken periodically, say once each month or oftener, will insure that none of the cells can be in trouble for more than a few days without detection. Information of this kind if properly made use of will tend to prevent low battery voltage, increase the battery plate life and save maintenance expense.

Consider, for example, a 16 cell axle lighting battery, in connection with which 32 volt lamps are used. With all of the cells in good condition and fully charged, the terminal voltage of the battery will be about 32 when the normal lamp load is being carried by the battery, and about 28 when the battery is nearly discharged. The voltage at the lamps, due to circuit losses, will be none too high at any time the battery is carrying the lamp load. It is, therefore, important that the battery should always be in such condition that it may furnish current for the lamps at as high a voltage as possible. The 4 volt drop in terminal voltage, from 32 to 28, of a battery during normal discharge is accepted, although under protest, only because it is looked upon as being unavoidable; but this acceptance does not constitute a license for allowing a battery to remain in such a condition that its terminal voltage, when fully charged, is only from 28 to 30, when carrying the normal lamp load. Such a condition demands an investigation. It is not the fact that the terminal battery voltage is 30 or 28, when experience has taught that it should be 31 or 32, that counts against a man, but his failure to make use of that fact. It is general practice to take terminal battery and lamp voltage readings on arrival of axle lighted cars at terminals, and it is not to be said that use is not made of them, but this indictment is more against the manner of usage than the use.

Possessing the knowledge that the voltage of the battery is, say, two volts lower than it should be, the repairman or inspector, usually proceeds to apply a remedy. There are a number of ways to go about it, and he takes the one he considers the best. Unfortunately, the repairman does not always select the best method, usually through ignorance. It is frequently the practice, without making further investigation than to determine that the terminal voltage is somewhat low, to give the battery a "boost" on the supposition that it has failed to receive sufficient amount of charge en route, notwithstanding the fact that there may be no indications that it has not received all the charging current it should need during the trip just completed. His guess may be that 3 or 4 hours of charge will be about what the battery needs. His conscience is clear, as he may think that he has satisfactorily taken care of the situation. He will be at a loss to know the reason for the battery needing another "boost" a few days later when a subsequent voltage test reveals conditions identical with what he found on previous test. Instead of "boosting" the battery it possibly may be assumed that the battery is low in voltage because of not having received sufficient charge en route and that it will come up to full charge on the next trip. This is the most convenient way to take care of the trouble, but obviously the least effective. The repairman may disdain these easy ways of taking care of the trouble, and instead take specific gravity readings of all battery cells, using up considerable time if carefully done. The readings obtained will mean little, unless compared with readings taken under similar conditions of charge and with the same degree of care and when the cells of the battery were known to be in good condition. At most the readings will indicate that either all of the cells are low in gravity, or that certain ones are. Unfortunately, conditions under which axle light batteries are operated are so varied and uncertain that the gravity method, although effective if followed up diligently and with an appreciation of the many things that may affect the specific gravity readings, is not generally a popular way of determining the reason for low battery voltage.

A method, which is used by many and the one here recommended, is to take a voltmeter reading of every cell in the battery while it is on discharge. If the battery as a whole is in good condition, all of the cells will read approximately alike. If a few cells only read low, and the remainder high and alike, then it may be quite safely assumed that the low cells are in need of special attention; also, that they are the cause of the low terminal voltage. It is obvious, if such a condition exists, the battery does not need charging until after the cause of the low cells has been removed. The usual procedure in a case like that cited above is to read the battery terminal voltage with full lamp load on, and if found to be unexplainably low, read the voltage of every cell of the battery while the lamp load is carried by the battery. In case all cells read alike, but low, it is probable that the battery needs to be charged. How this shall be done is for the person in charge to say. If a cell reads low while the others read relatively high, it may be assumed that there is something wrong with that particular cell. The cause may be external and easily located, but if not, then the connectors should be disconnected and the cell cover removed. A careful examination of the plates should be made in order to locate any short circuit between them. If no evidence of trouble is found, the plates should be removed from the tank and a search made for short circuits. It may be found that two plates of opposite polarity are touching, that a positive and negative plate are both touching the lead linings, or that sediment is short circuiting the bottoms of the plates. Regardless of what may be the nature of the trouble the cause should be removed before the plates are replaced in the tank. Care should be exercised when assembling the cells after repairs have been made in order to make sure that all separators and liners are in good condition and in place. This precaution will, many times, save needless expense later. If facilities for giving the cell an individual charge, after repairs have been made, are available, this should be done and the charge continued until the cell is in approximately the same condition, so far as charge is concerned, as the good cells of the battery. If this is not possible the cells should be replaced after having been repaired and provisions made so that the whole battery will receive en route an overcharge equivalent to about its rated capacity.

The query is often made, "Why, if this method of locating trouble is effective, is it not more generally made use of?" The answer is that the idea probably does not appeal so strongly to others as it does to the writer, who believes that if the method as outlined was generally used, and if those in charge of axle light equipment were kept cognizant of the individual cases of battery cells falling out of step with the other cells of the battery, it would lead to investigations resulting eventually in effectively preventing the great majority of cases of trouble of that nature.

Electric Battery Locomotive, Midland Railway

Some eighteen months ago the Midland Railway Company put to work a battery operated electric locomotive, for shunting and sorting coal traffic at the West India Docks Depot, London. The work was previously performed by horses in connection with a number of turntables situated in each road, and investigation showed that the work could be performed more satisfactorily and economically by an electric locomotive than by horses, hydraulic or electric capstans and snatchheads.

A locomotive is also considerably more flexible in operation than any of the alternative arrangements, and as the ordinary steam locomotive cannot enter the yard, the only access from the railway being by means of an hydraulic wagon lift, the whole of the work had to be performed by the electric locomotive.

High speeds are, of course, unnecessary in working a yard of this type, and the maximum speed attained with full load is only about seven miles per hour, speeds up to twelve miles per hour being attained with light loads. The rated capacity of the locomotive is six loaded wagons, weighing 15 tons each, and twelve light wagons of approximately 6 tons each.

The weight of the locomotive complete with battery is 17½ tons, and the wheelbase, which is, of course, rigid, is 8-ft. 6-in.

The general appearance and method of construction of the locomotive is well shown in the photograph attached.

There are two motors—one per axle—of 22 h. p. each, supplied by Messrs. Dick Kerr & Co. The battery, which is situated in the two end compartments, was provided by the "D. P." Battery Company, Ltd., of Bakewell. It consists of 108 cells, 21-plate TL. type, and has a capacity of 300 ampere-hours. The cells are of the D. P. Battery Company's standard train-lighting pattern in lead-lined teak boxes, and are fitted with "block" type lids.

It is important to note that the locomotive has not been out of service at any time on account of the failure of the battery, and that no single cell has failed since put to work about 18 months ago. The battery has been in daily use (except Sundays), the discharge rate varying from 40 to 90 amperes, with occasional spurts up to 150 amperes.

The battery is charged every day from about 12.30 p. m. for one to two hours, and a "refreshing" charge is given in the early morning. When the battery was cleaned out the work was done without interrupting the service in any way, and the plates were found to be in excellent condition.

Control is by the ordinary series parallel method, providing two economical running speeds, but no restrictions are put on the drivers with regard to the use of the other notches. Breaking is of the rheostatic type, operated by the main controller, this method being very useful for shunting operations. A band brake with hand operation is also fitted to each axle.

The mechanical portions of the locomotive are largely constructed of standard wagon parts, *e. g.*, the wheels, axles, draw-gear, etc. The body and cab are of wood, suitably braced with iron-work. The covers over the battery compartments are arranged to drain off all rain water, while both sections are so ventilated that gases given off during charging or working the battery are carried away.

Charging is performed by a motor generator, the voltage of supply from the Poplar Borough Council of 460 volts, being too high to offer any advantages for the use of a reverse booster. The generator is differentially compounded, so that after current is switched on, further attention is unnecessary except in the case of a gassing charge.—*The Locomotive,* London.

Electric Train Lighting With Headlight Generators

There are certain classes of passenger train service where it is desirable to use a system of electric lighting that requires little or no expert attention and one that is considerably lower in first and operating costs than the systems in general use. The development of turbo-generator equipment for locomotive headlight service to a point where it is reliable and possesses close voltage regulation has made possible its use for the electric lighting of trains in certain classes of service. The small capacity of the generator set and the fact that it is impractical to use storage batteries with it confines the use of this head-end system of electric lighting to trains of short length and to trains which can be operated intact, including the locomotive, throughout their entire run. As common to all forms of head-end system, where no secondary lighting is provided, the cars can be operated only in trains properly equipped.

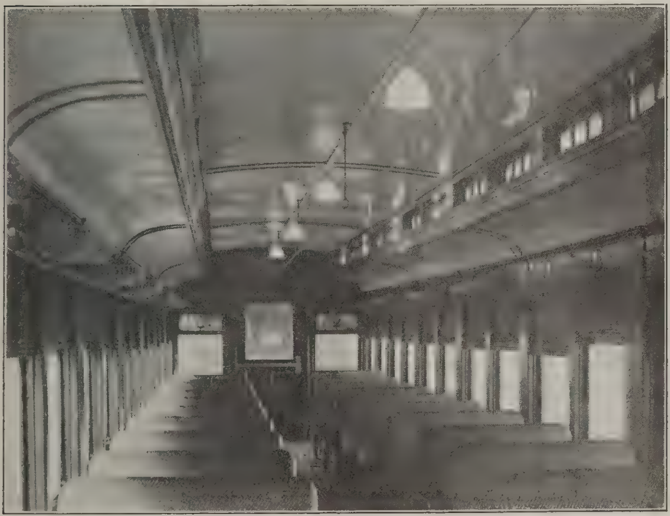


Fig. 1. Interior View of a Coach on the Staten Island Lines of the B. & O. System, Showing Method of Mounting the Electric Fixtures. It Will Be Noted That the Old Oil Lamps Have Been Removed.

It is the object of this article to describe the methods used by the Baltimore & Ohio and the Chicago & North Western in adapting this form of head-end train lighting to certain of their suburban trains. The installation on the Baltimore & Ohio trains will be described first.

Baltimore & Ohio

The operating conditions of passenger train service on the Staten Island Railway and the Staten Island Rapid Transit Railway, subsidiary companies of the Baltimore & Ohio system, are admirably adapted for the use of this head-end system. With a view to improving the lighting of these cars which have, heretofore, been using oil lamps and also to reduce their maintenance costs, electric lighting is now being installed on the entire passenger equipment. These railroads operate on Staten Island, N. Y., the passenger service being exclusively suburban and local in character, while the equipment is of smaller size than standard steam railroad passenger cars and cannot be operated with them.

Voltage

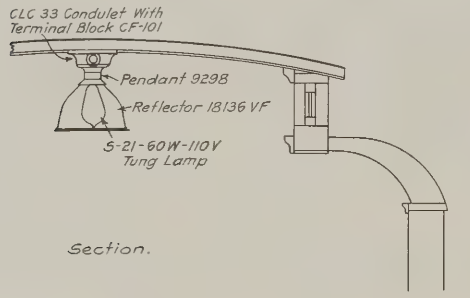
The 110-volt, two-wire train line, head-end system has been installed, current being supplied from special turbine-generator headlight equipment mounted on the locomotive. No batteries are employed. The 110-volt system was chosen to permit lighting the cars at the terminal point from the station service if it was ever found desirable to do so and further to permit using small size train line wires. On account of these cars being unable to operate and interchange with other railroad equipment, the objection to adopting the special voltage does not hold good in this case.

Turbo-Generators

The turbine-generator equipments are of special design, and are of 2,500-watt capacity, with generators wound for 110 volts. There are 24 equipments being installed, 12 furnished by the Schroeder Headlight Company and 12 by the Pyle-National Electric Headlight Company. Views of these generators mounted on the locomotive are shown in Fig. 3 and Fig. 4. Separate views of the turbine-generator with their cross-sections are shown in Figs. 5, 6, 7 and 8. The capacity of 2,500 watts was required on account of the lighting load of the train, the normal maximum length being six cars, with an occasional train of eight cars.

Fixtures

The cars are equipped with four or five lighting fixtures, depending on the length of the cars, at approximately three seat spacing. Standard 60-watt, 110-volt tungsten lamps with Holophane, velvet finished reflectors are employed. The fixtures are of the pendant type, designed primarily for street car service and are mounted on condulet fittings, the conduit being located on the ceiling of the car. There is but a single lighting circuit per car, which eliminates the necessity of a switchboard panel, a standard condulet type of box with switch and cut-out being used instead. A daylight interior view of one of the Staten Island coaches, which is equipped with five 60-watt fixtures, is shown in Fig. 1, and detail drawings showing the method of wiring these cars are shown in Fig. 2.

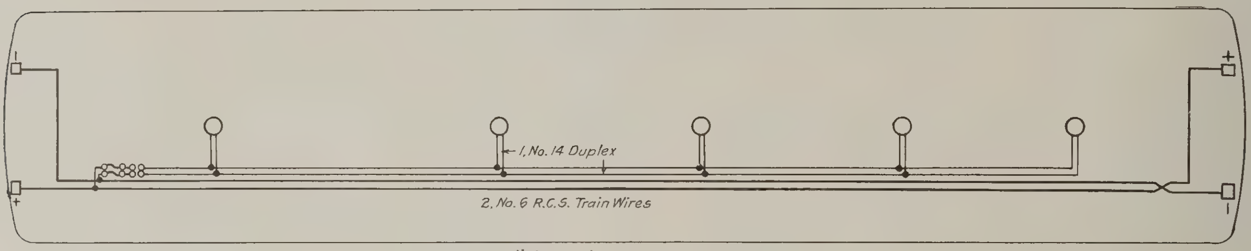


Section.

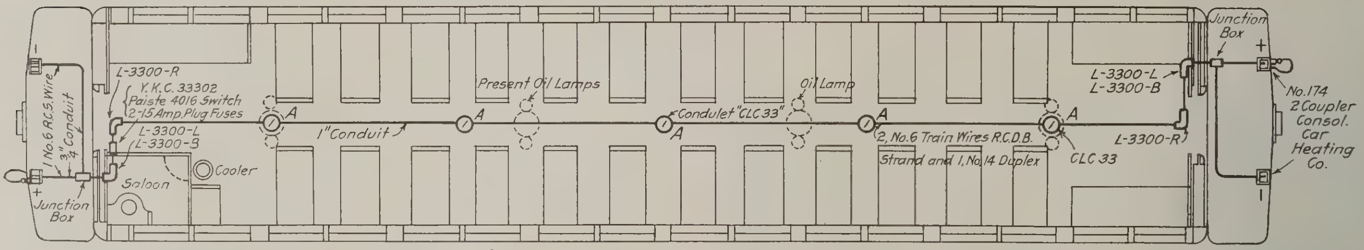
Note: Fixtures marked "A" to be mounted on center deck, condulet to be "CLC 33" with gray lead finish outside, and with terminal block "CF-101." 1" conduit run exposed on, and painted to match head lining.

Fixture Data

Circuit Number	Number of Lamps	Fixture, Cat. Number	Location	Type	Size of Lamp Volts-Watts	Reflector
			Passenger Coaches			
1	5	9298	Passenger Compr't.	Pendant	S-21-60W-110V Tung	18136 V.F
			Combine Cars			
1	4	9298	Passenger Compr't.	Pendant	S-21-60W-110V Tung	18136 V.F
1	1	9298	Baggage Compart.	Pendant	S-21-60W-110V Tung	18461



Wiring Diagram.



Conduit and Floor Plan - Passenger Coaches.

Fig. 2. Detailed Drawings Showing Method of Wiring the B. & O. Coaches for Electric Lights.

Wiring System—First Plan

By referring to Fig. 2, it will be noticed that the current enters and leaves each car through two special electric connectors and connector receptacles located on each end of the car under the platform. From there the two No. 6 train wires are brought to a junction box through ¾-in. conduit and on through the car together in 1-in. conduit. This 1-in. conduit does not go under the floor, but rises at each end of the car and is taken through the car interior on the ceiling, forming the conduit system for the lamp circuit as well as for the main train wires. By referring to the wiring diagram in Fig. 2, it will be seen that the lighting circuit is tapped on the train wires in a cast iron switch box located in the main conduit going through the saloon. This light circuit consists of one No. 14 duplex and is run in the 1-in. conduit containing the two No. 6 train wires.

Wiring System—Second Plan

The plan above described is the one first used, but on the last cars wired a different plan was used, which effected a saving of about $10 a car, in material and labor. The essential differences between the first plan and the second plan is that with the latter the main train wires were run from one end of the car to the other through a ¾-in. pipe underneath the floor of the car. The lamp circuit taps this train line in a junction box at one end of the car and is taken up through the saloon and along the ceiling in ½-in. conduit. In this way a considerable saving in No. 6 wire was made, some condulets were eliminated and in addition it was found that the labor charge with this system was less, because of the ease of working the ½-in. conduit. It is true that an additional length of conduit was run the entire length of the car, but all things considered, the second system, as already mentioned, effected a considerable saving per car.

Train Connectors

A special car coupler or car connector for the electric circuit has been used, being located below the car platform. These couplers were manufactured by the Consolidated Car Heating Company and were designed originally for use on certain elevated lines in New York

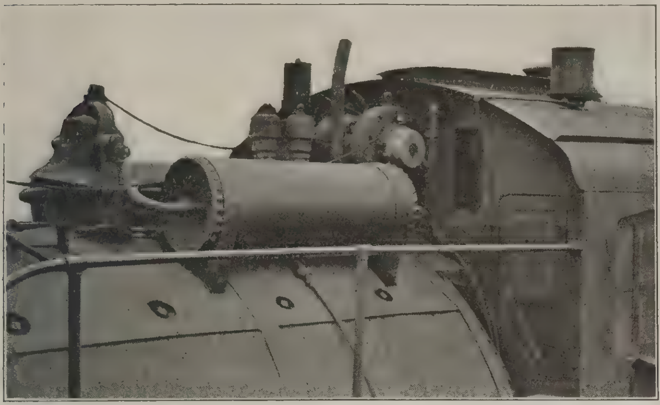


Fig. 3. Application of a Schroeder Type 4-J, 2.5 k.w. Turbo-Generator on a Staten Island (B. & O.) Locomotive.

for carrying the electric lighting circuits through the train. The jumpers are of single conductor type, one side of the circuit being run on one side of the car and one on the other. The purpose of using a coupler of this general design was to secure a construction in which one end of each jumper is permanently attached to the car wiring. In this way each end of each car now contains on one side a flexible jumper with a plug and on the other a receptacle for the plug which is attached to the other car.

The installation cost for car wiring, conduits and fixtures, is approximately $75.00 per car and $210.00 per locomotive, the latter cost including the turbine equipment.

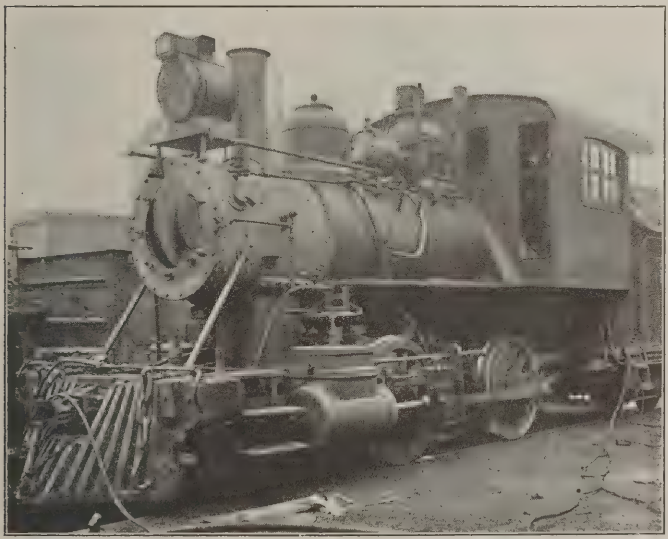


Fig. 4. Application of a Pyle 2.5 k.w. Turbo-Generator on a Staten Island (B. & O.) Locomotive.

Tests made on these trains show a satisfactory voltage regulation, the maximum variation not exceeding five volts within the normal load of the turbine and working limits of the steam pressure.

Material Used

The accompanying bills of material show the electrical material used in wiring the cars in accordance with both the first and second plans as mentioned above.

Other Installations

The same general system of head-end lighting is also being installed on two or three trains in local or branch line service on the Baltimore & Ohio System. In this case the 30-volt system with the standard M. C. B. train line jumper connection between cars (Gibb connector) has been adopted to conform to the standard train lighting practice. This permits cars equipped with other systems of electric lighting, but provided with a standard train line, to operate in these trains without interfering with the head-end system for the remaining cars and also in case the branch line cars should occasionally get into main line service they can be lighted by train line connections from an axle generator car.

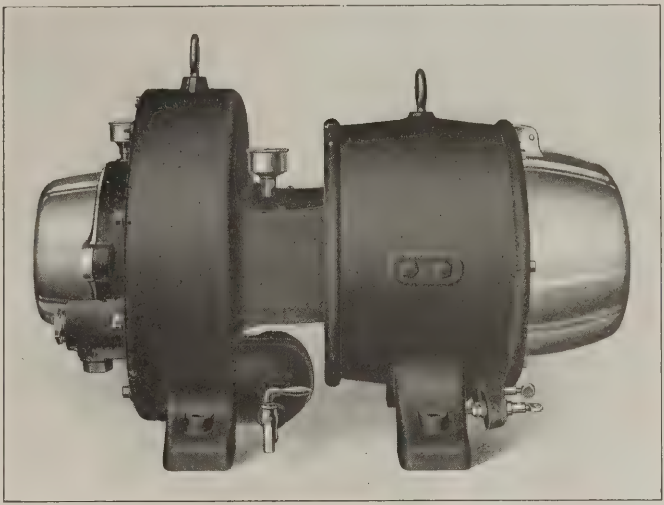


Fig. 5. The Schroeder Headlight Company's Type 4-J, 110 Volt, 2.5 k.w. Turbo-Generator.

When considering the advantages of lighting such suburban trains by electricity instead of oil, it should not be overlooked that the installation of this system not only provides electric lights in the cars but also provides electric headlights and cab lamps for the locomotives. It is also expected that this system will prove very economical in operation.

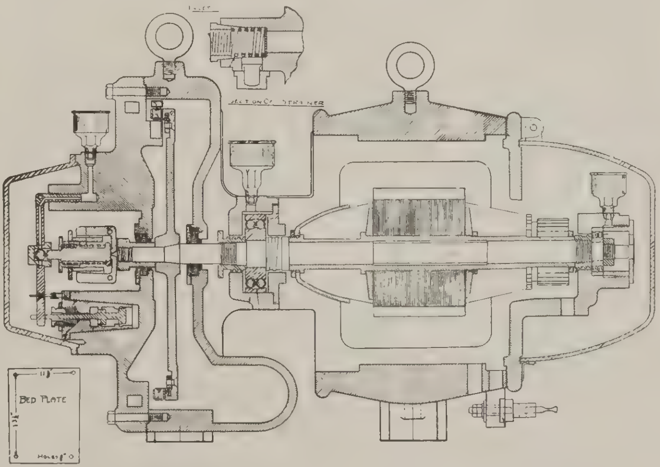


Fig. 6. Sectional View of the Schroeder Turbo-Generator.

Lamp Renewals

On the Staten Island Lines it has been found that out of a total of 94 cars containing about 470 lamps, only one lamp is replaced per day and that from present indications the average life per lamp for the service mentioned will be about six months.

Bill of Material—First Plan

80 ft. 1″ conduit pipe.
30 ft. ¾″ conduit pipe.
196 ft. No. 6 rubber covered wire.
50 ft. No. 14 rubber covered Duplex wire.
2 1″ conduits, type L. L.
2 1″ conduits, type L. R.
1 1″ conduit, type L. B.
1 1″ plus 1″, type U. N.
4 1″ plus ¾″, type U. N.
5 1″ conduits, type C. L. C.
1 1″ conduit, type Y. K. C.
5 conduits, type Pendant.
4 1″ plus ¾″ bushings.
2 sets cord couplings.
4 angle irons 6″ plus 4″ plus ¼″ plus 2½″.
8 2″ plus ¼″ stove bolts.
22 4″ plus ¼″ stove bolts.
12 1½″ No. 16 wood screws.
4 1″ pipe straps.
1 cut out and switch No. 701.
2 15 ampere fuse plugs.
1 roll friction tape.
½ roll rubber tape.
¼ lb. strip solder.
5 parabola shades.
5 60 watt 110 volt lamps.

Bill of Material—Second Plan

70 ft. ¾″ conduit pipe.
50 ft. ½″ conduit pipe.
130 ft. No. 6 rubber covered wire.
56 ft. No. 14 rubber covered wire.
3 1″ condulets, type T.
1 ½″ condulet, type L. L.
4 1″ plus ¾″ condulets, type U. N.
5 ½″ condulets, type C. L. C.
1 ½″ condulet, type Y. K. C.
5 condulets, type Pendant.
4 1″ plus ¾ bushings.
2 set cond. couplings.
4 angle irons 6″ plus 4″ plus ¼ plus 2½.
8 2″ plus ¼ stove bolts.
22 1½″ No. 16 wood screws.
4 ¾″ pipe straps.
2 15 amp. fuse plugs.
1 cut out No. 701.
1 roll friction tape.
½ roll rubber tape.
¼ lb. strip solder.
5 parabola shades.
5 60 watt 110 volt lamps.

Maintenance

At present the following plan for maintaining the electric lights on the Staten Island trains is used: One man is regularly assigned to this work and is on duty five hours in the morning, from seven to twelve, and for five hours in the evening, from seven o'clock until midnight. This man goes to the yards near the Clifton shops the first thing in the morning and thoroughly inspects all turbines and dynamos on the engines which are in the yard at the time, making a report of all defects to the master mechanic. He then goes to the main terminal at St. George and inspects all coaches and engines as they arrive. In the evening this inspector remains in the terminal depot at St. George and sees that all lamps and turbine-generators are in operating condition. It is the duty of the trainmen to take care of all train connectors.

An extra turbine-generator set is kept on hand at the Clifton shops for emergencies, which can be installed in place of one which has been found defective, in 45 minutes by using a block and tackle. Plans are being considered to reduce this time to twenty minutes by using a small pole and outrigger derrick which will be located at a certain point in the Clifton shop yards.

The first electric lighted train on the Staten Island Lines has been in service since about August 1, or for a period of about nine months, during which time all parts of the equipment have given good satisfaction. In the opinion of railroad officers who have watched its performance, this system of electric train lighting is a success, for this particular kind of service.

The Chicago and North Western

In August, 1915, a train running between Chicago and Aurora, consisting of one combination baggage and smoking car, and six coaches, or a total of seven cars, was equipped with electric lights, the installation consisting of a standard 1.5 k. w., 32-volt, Pyle National turbo-generator mounted on the locomotive, 5 32-volt, 40-watt Tungsten lamps in the body in each car and one 15-watt Tungsten lamp on each platform.

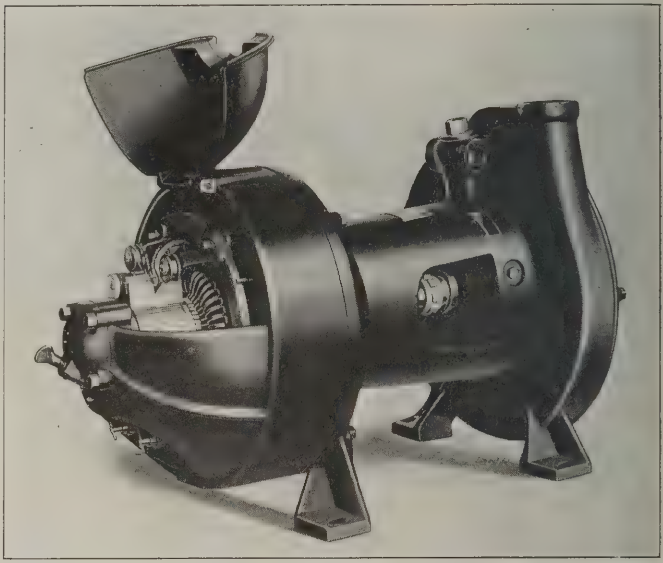


Fig. 7. The Pyle-National Electric Headlight Company's 2.5 k.w. Turbo-Generator.

Fixtures

The five 40-watt lamps in the body of the car were installed in the original gas fixture so that no change was necessary in the fixture itself other than adapting it for the electric light. The two lights over the platform were installed in the ordinary manner. With this equipment the lighting was not as satisfactory as it should have been owing to the variation in voltage caused by the overloading of the generator. In order to remedy this, 25-watt, Mazda C lamps were installed instead of the 40-watt vacuum filled lamps. This, of course, cut down the load

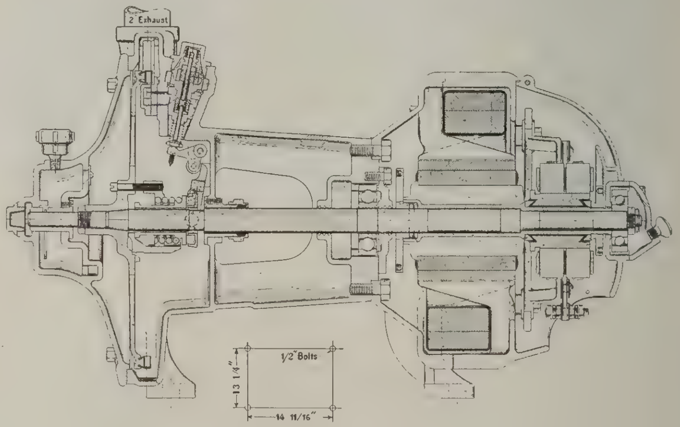


Fig. 8. Sectional View of the Pyle Machine.

appreciably but it developed that the intense light from the small filament of the Mazda C lamps was objectionable. To remedy this defect they were bowl frosted, which, of course, cut down the quantity of light and again the lights were not satisfactory owing to its insufficiency.

The Turbo-Generator

It was then recommended that for a train of five cars or over a larger generator should be used, subsequently the locomotive was equipped with a 32-volt, 2,500-watt Pyle National headlight turbo-generator. The locomotive equipped with this generator was placed in the train above mentioned and the 25 watt, Mazda C lamps were replaced with the 40-watt vacuum Tungsten lamps and the 15-watt lamps were retained over the platforms. With this equipment it was found that the voltage remained practically uniform and since the installation of the 2,500-watt equipment there have been no complaints whatever. On the contrary the lighting has invariably been reported as satisfactory in all respects.

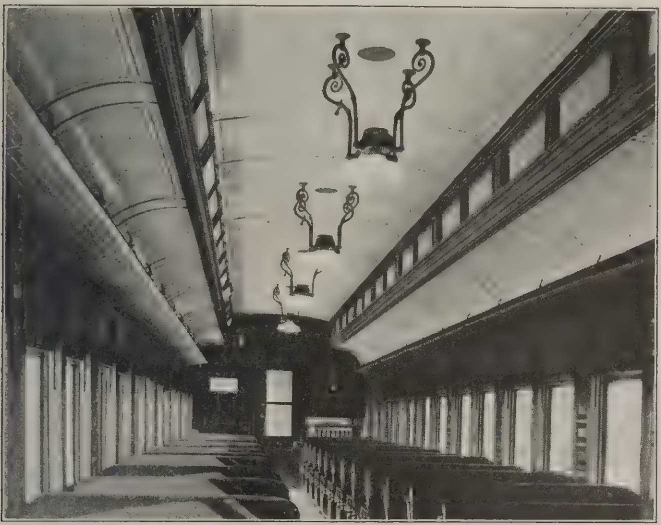


Fig. 9. Interior View of a C. & N. W. Coach, Showing Electric Fixtures.

It will be noticed that from the above tabulation of lamps in the car, that the load was 230 watts per car. An interior view of one of the Chicago & North Western coaches, which is equipped with electric lights in the made-over gas fixtures, is shown in Fig. 9.

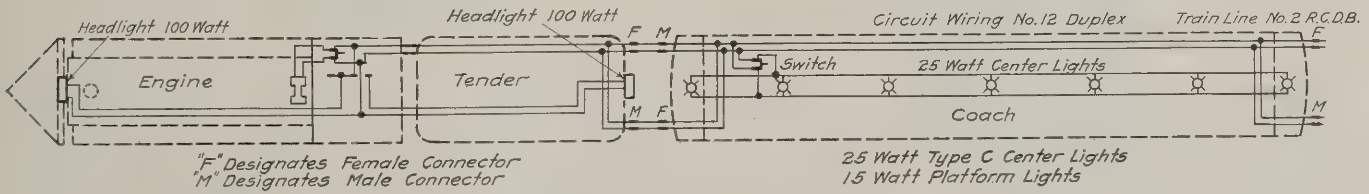


Fig. 11. Wiring Diagram of C. & N. W. Locomotive and Car. Additional Cars Would Be Wired the Same as the One Shown.

Method of Car Wiring

The method of wiring the cars for electric lights may be described as follows: Two No. 2 wires, rubber covered, double braid, were carried in conduit underneath the cars and run to proper connectors at either end of the car under the platform. Two, two-wire connectors were placed at each end of the car so that no matter which way the car was turned the parts would come together in their proper relation. The connectors used were made by the Ralco Manufacturing Company of Chicago and are so arranged that there are no live parts exposed at any time.

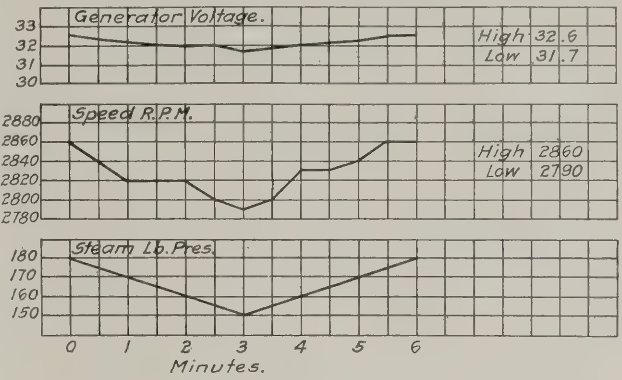


Fig. 10. Results of a Test on a 2.5 k.w. Pyle Turbo-Generator While Lighting One Car Taking a Constant Current of 15.7 Amperes, and While Generating a Normal Voltage of 110. All Readings Are Reduced to 32 Volt Standard and Curves Show the Same Relative Increase or Decrease in Per Cent of Full Normal Voltage. Steam Very Wet.

Other Installations

In addition to the above installation the Chicago & North Western has recently installed electric lights in two trains on their Northern Iowa division running between Eagle Grove and Fox Lake and between Elmore and Lake Crystal, Minn. These trains consist of three cars, each wired in the same manner as described above with the exception that the old oil lamps were remodeled to take electric lamps. In this installation the standard Pyle 1-kw. headlight generating set is used and when making tests on these trains it developed that, with the incandescent lamps used in the headlight proper, it would be possible to light a train of from four to five cars satisfactorily and, with the arc headlight burning, it would be possible to light three or possibly four cars.

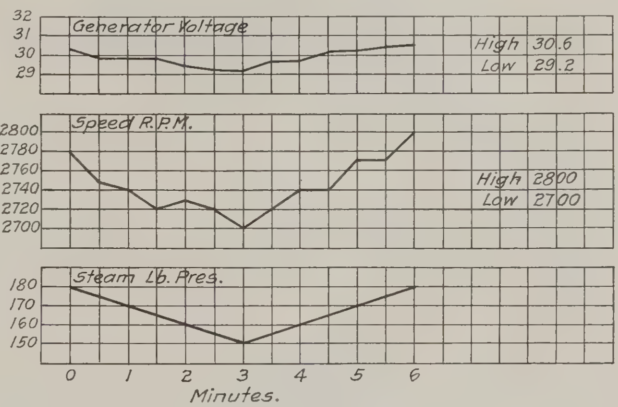


Fig. 12. Results of a Test Similar to the One Mentioned in Fig. 10, Except That the Load Consisted of 10 Cars Taking a Constant Current of 78.4 Amperes.

Tests

Voltage reading taken on the seven-car train running between Chicago and Aurora with both the 1.5 kw. and the 2.5 kw. Pyle headlight generators are given in Figs. 13 and 14. These curves show that the maximum drop in voltage between the first and last cars is approximately four volts which compares favorably with the voltage drop obtained with the three-wire system used on the longer first-class trains. For this reason, it seems that the use of a two-wire train line in installations of this kind is justified especially when the saving in first cost of wiring the cars is considered.

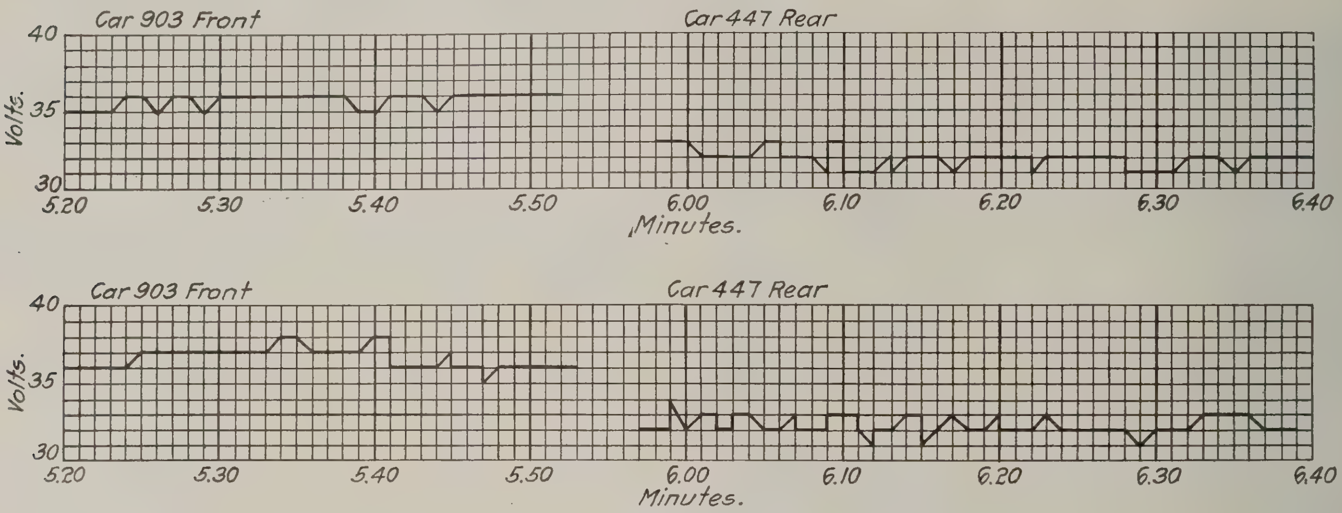


Fig. 13. Voltage Readings Taken on C. & N. W. Suburban Electric Lighted Train Equipped with a Standard Pyle 1.5 k.w. Headlight Generator. The Train Consisted of Seven Cars All Equipped with 40 Watt Mazda Lamps, the Total Load Being 1,920 Watts.

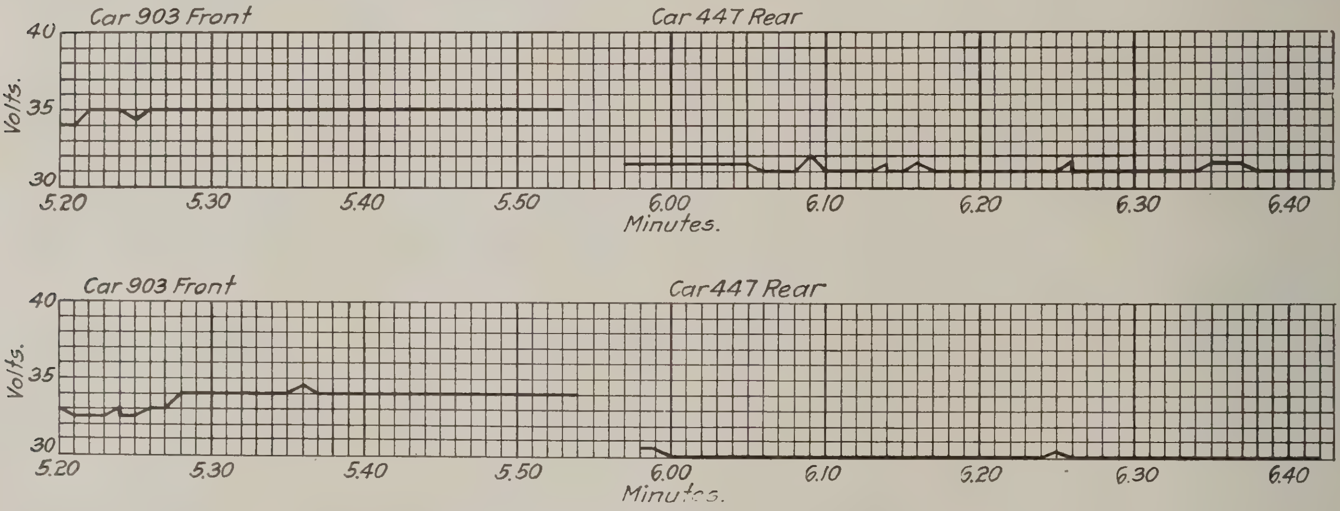


Fig. 14. Voltage Readings Taken on the Same Train Referred to in Fig. 13, After the 1.5 k.w. Generator Was Replaced with a Larger Machine of 2.5 k.w. Capacity.

Effect of Varying Steam Pressure

Some curves showing the effect of varying the steam pressure upon the generator speed and generator voltage under various loads are shown in Figs. 10 and 12. These tests were made with a 110-volt turbo-generator of 2.5 kw. capacity but all readings have been reduced to a 32-volt standard so that the curves show the same relative increase or decrease in per cent of full normal voltage as would be obtained if the generator was wound for 32-volts instead of 110 volts. The steam supply-pipe, connected to the turbine under test, was ¾ inches, the exhaust pipe was 2 inches and a test steam gage, with a range of zero to 300 lb., was applied to the turbine valve. Variations in steam pressure were accomplished by a hand operated reducing valve in the steam supply-pipe and the speed indicator was applied to the turbine end of the shaft. It will be noticed that the curves in Fig. 10 are results of a test with a one car load while those in Fig. 12 are results of a test with a 10 car load.

It is the opinion of the railroad officers who are in charge of this equipment that this headlight system of train lighting is extremely efficient and can be used in many instances but as to whether it is adapted to all classes of suburban and branch lines service or not remains an open question. For the classes of service already mentioned, however, including suburban and branch line runs this system of train lighting has been very successful when properly installed.

The evident advantages of this system of electric train lighting are: economy of maintenance and operation, more and better light, and cleaner cars due to entire absence of oil and smoky lamps. Another advantage is that only one generator unit is used which does not require battery auxilliary for the stops. This is one reason for the low maintenance costs.

Shop Motor Section

Transformers

J. H. Wickman*

XIX

Thus far under the subject of transformers only those that are used for lighting and power work have been considered, but under this head it is desired to explain the different types of special transformers that may be classified as follows:

1—Potential transformers,
2—Current transformers,
3—Constant current transformers,
4—Subway transformers.

Potential Transformers

Potential transformers are used to reduce the bus-bar or line voltage to a value suitable for standard switchboard or other instruments and to insulate the meters from the high potential circuit. As they are principally used in connection with measuring instruments, they are designed for extreme accuracy, and as they constitute a barrier between the line, or bus-bar and the switchboard attendant they are also designed with high insulation.

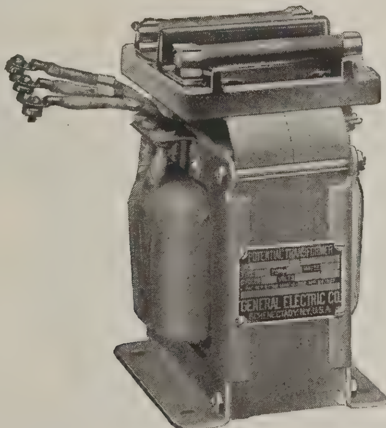


Fig. 60. 2,200-Volt Potential Transformer with Fuses.

Potential transformers are similar to the power transformers, already covered in these articles, in construction and connection details.

Some of the potential transformers manufactured by the General Electric Company are shown in Figs. 60, 61 and 62. The transformer shown in Fig. 60 is known as Form E-2 and is designed for voltages up to and including 2,200 volts. Form E transformers are of new design, are of 50 and 200-watt capacity and supersede the old transformers with the marble base. They represent the latest improvement in potential transformer design and show improved ratio accuracy and small phase angle displacement. These 2,200-volt transformers are equipped with primary fuses and fuse holders, shown in Fig. 60. Transformers of this type which are equipped with primary fuses and fuse holders are known as Form E-2 and transformers without fuses are known as Form E-1. For voltages below 2,200 volts primary fuses are not furnished with the transformer and these are also known as Form E-1. The 3,300 and 4,400-volt transformers,

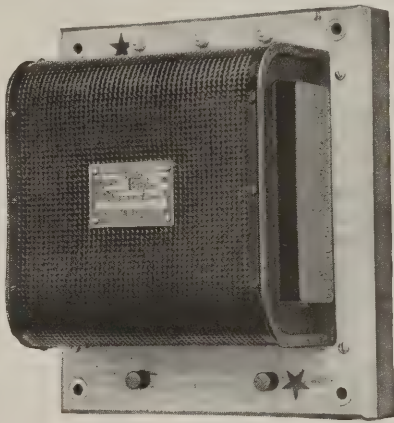


Fig. 61. 3,300 and 4,400-Volt Potential Transformer.

as shown in Fig. 61, are furnished on marble bases. These transformers and all transformers above 2,200 volts are furnished in 200-watt capacity only. All potential transformers for voltages above 6,600 are all insulated and have cast iron tanks and large insulator terminals which carry the fuses with barrier between. A transformer of this type for 11,000 to 24,600 volts is shown in Fig. 63.

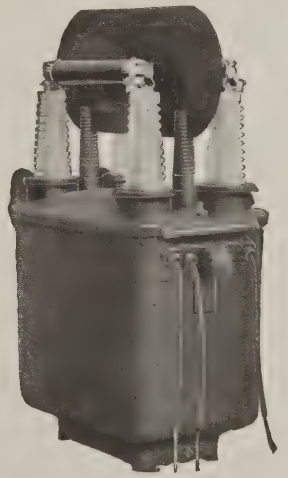


Fig. 62. 11,000 to 24,600-Volt Potential Transformer.

Special Instructions

1—Special care should always be taken to ground the case or frame of all potential transformers.

2—A wire of sufficient size should always be used so that the drop in the connection between the transformer and the instruments will be negligible; otherwise the readings of the instruments would be affected.

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*General Foreman, Electric Department, Illinois Central, Chicago.

3—Great care should always be exercised when replacing the primary fuses so as not to get a short circuit or start an arc.

4—A sure way to tell that the primary fuses have blown is to see if there is any voltage across the secondary terminals of the transformer, at the transformer itself, with a portable voltmeter or a lamp. If the lamp does not light, or if the voltmeter does not show any reading, it is almost certain that the primary fuses are blown. The switchboard attendant will always know that something is the matter in a case of this kind, as the switchboard instruments will not show any indications, with the exception of the ammeters.

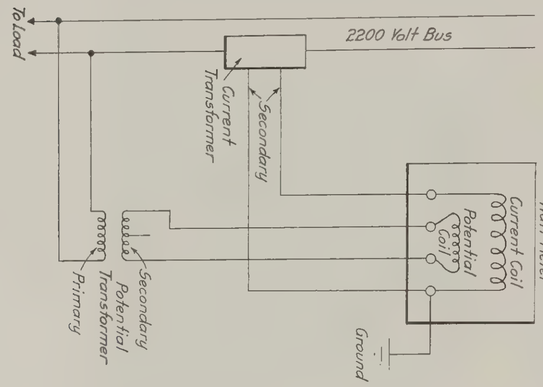


Fig. 63. Wiring Diagram of a Single-Phase Wattmeter Connected to a Single-Phase Circuit Through One Potential and One Current Transformer.

5—Special instructions for the installation of these transformers, which are sent out with them, should always be followed to insure good operation.

6—There are no complicated connections with these transformers. The primaries are connected directly across the bus-bar or lines, and the secondaries are carried out in a simple two-wire system.

7—Many companies require one side of the secondary to be grounded so as to give even greater protection to the switchboard attendants.

Connections

A wiring diagram of a single-phase circuit that would require a potential and current transformer is shown in Fig. 63, while Fig. 64 shows the connections necessary for two potential transformers connected open delta for use on a three-phase circuit. In both cases it will be noted the primary coils are connected across the line, and the secondaries are in this case run to a watt meter; however, the secondaries are used in connection of different instruments, such as the voltmeter, power-factor indicator, frequency meter, etc., which will be taken up later under meters.

Current Transformers

Current transformers are designed and used for two purposes, namely, to reduce the line current to a small value suitable for measuring instruments and to insulate the meter circuit from the high potential circuit. The construction of the current transformer no doubt requires more accuracy than any other type of transformer. It is composed of a primary and secondary winding, and a very small amount of laminated iron is used as compared with any other type of transformer, and in fact the ideal current transformer would be constructed without iron. There are few turns only in the primary winding, and in some cases only one turn, which is a large diameter wire or copper strap, while the secondary is made up of many turns of smaller sized wire, usually of a No. 10, round or strap wire. The ratio of turns in the primary and secondary required in the current transformer are an exact multiple of each other—that is, if there are two turns in the primary and the ratio is 40 to 1, there would be 80 turns in the secondary winding.

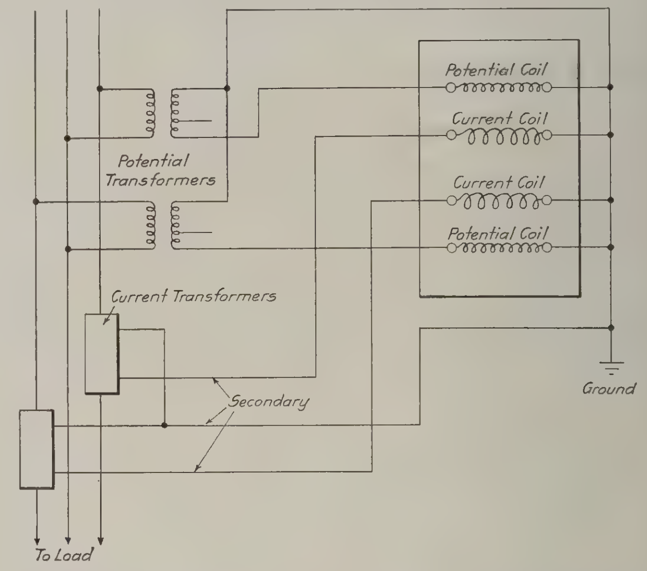


Fig. 64. Wiring Diagram of a Polyphase Wattmeter Connected to a Three-Phase Circuit Through Two Potential and Two Current Transformers.

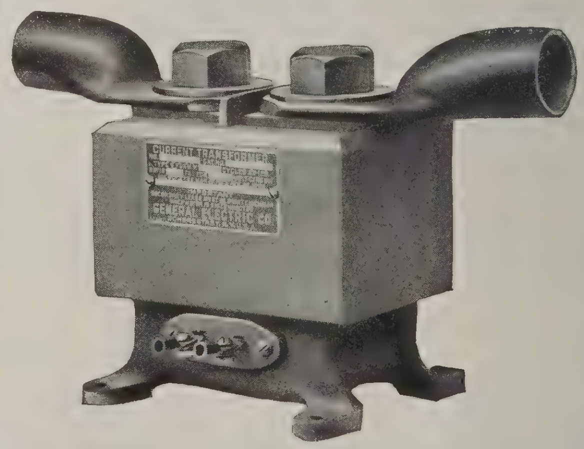


Fig. 65. Form K6 Current Transformer for 2,500 Volts, Capacity 15 Volt-Amperes.

All manufacturers of current transformers do, by agreement through different societies, color the leads entering both the primary and secondaries—that is, one end of each of the primary and secondary may be marked red and the opposite end on each may be painted white. This is done to show the instantaneous direction of flow of current through the secondary with reference to that of the primary and when connecting two or more current transformers, as in Fig. 64, if the two ends that are marked red be connected so they face the load side, the secondary red ends also must be kept in the same relation.

Current transformers are used wherever the voltage of a circuit exceeds 1,000 volts and although the secondary is usually designed to carry only 5 amperes at full load, the instruments connected to it are calibrated to indicate the main line current or power as the case may be.

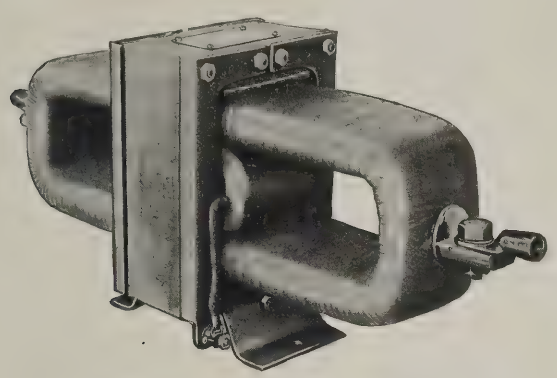


Fig. 66. Form K28 Current Transformer for 2,500 to 15,000 Volts, Capacity 40 Volt-Amperes.

Current transformers, like potential transformers, are of two types, namely, dry and oil insulated.

Dry Type

The dry type current transformer resembles the dry type potential transformer and is composed of two coils, primary and secondary. The primary coil is always connected in series with the main line and is at the main line voltage. It should, therefore, be treated as part of the high potential system. This type is used on circuits carrying voltages of 15,000 and less.

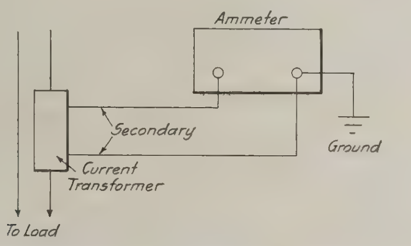


Fig. 67. Connection Diagram Showing an Ammeter Connected to a Single-Phase Circuit Through One Current Transformer.

Two current transformers manufactured by the General Electric Company are shown in Fig. 65 and Fig. 66. The transformer shown in Fig. 65 is known as Form K-6, and being of low capacity should not be used with watt-hour meters when the secondary connected load is greater than 15-volt amperes. A similar transformer known as Form K-5 for 2,500-volt circuit may be used in connection with any combination of instruments, meters, etc., the combined load of which does not exceed 40-volt amperes. The K-6 transformer is designed especially for installation involving only ammeters or relays. The transformer shown in Fig. 66 is known as Form K-28 and may be used on circuits up to 15,000 volts. Like the Form K-5, it is rated at 25-125 cycles and has a five-ampere secondary winding and may be used in connection with any combination of instruments, meters, etc., the combined load of which does not exceed 40-volt amperes.

Oil Type

The oil type current transformer is used on very high potentials such as 33,000 to 140,000 volts and above. Its purpose and design is the same as the dry type, with the exception that the coils are immersed in a case filled with transil oil. This type of transformer is designed with high insulated bushings at the top which carry both of the primary connections, while the secondary connections are at one side of the case.

An outdoor type of oil current transformer is built with the insulating bushings composed of material like high tension insulators, and resembles several of these piled on top of each other. This outdoor type is generally placed on a platform located on a pole and used to operate trip coils to sectionalize the lines in case of trouble, or to be connected to measuring instruments for branch lines.

Ratios

Current transformers designed for a low secondary current, must have very high ratios between the primary and secondary turns in the windings. Thus a line that carries 800 amperes through the primary and has a 5 ampere secondary, must have a ratio of 160 to 1; that is 800 amperes in the primary and 5 amperes in the secondary circuit.

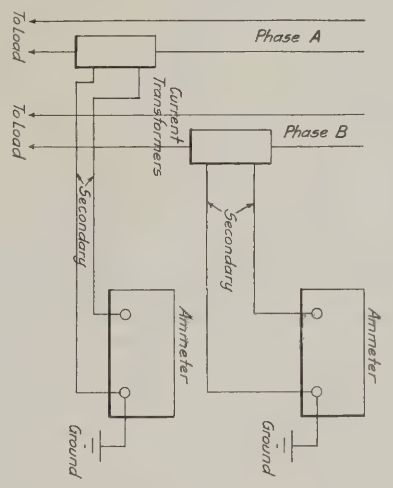


Fig. 68. Connection Diagram Showing Two Ammeters Connected in a Two-Phase Circuit Through Two Current Transformers.

The ratios of current transformers vary widely, the following being in general use: 1 to 1, 5 to 1, 10 to 1, 16 to 1, 20 to 1, 60 to 1, 80 to 1, 160 to 1, etc.

Operation

The current transformer, after being installed according to the directions always sent out with them, requires very little attention other than keeping it clean. The connections of the primary, as heretofore stated, is a series connection and likewise of the secondary circuit, which is always run so that all instruments connected to it have their current coils connected in series.

The secondary of the transformer must never be left open circuited. If for any reason it becomes desirable to remove a meter or open the secondary circuit, the secondaries should be short circuited at the transformer, while making the changes; or if the transformer is not very accessible a jumper can be put on so as to never leave the circuit open. These transformers are always shipped from the factory with the secondary short circuited by a piece of copper or a wire, and this short circuiting device should be left on until the secondary circuit is run and the attendant is sure everything is closed circuited before removing.

When installing current transformers one side of the secondary circuit should always be grounded and most manufacturers send out a special grounding device with each transformer.

Wire smaller than a No. 10 or No. 12 should not be used in the secondary circuit on account of the mechanical strength and resistance, the latter affecting the instrument correctness if resistance is introduced exceeding about one ohm.

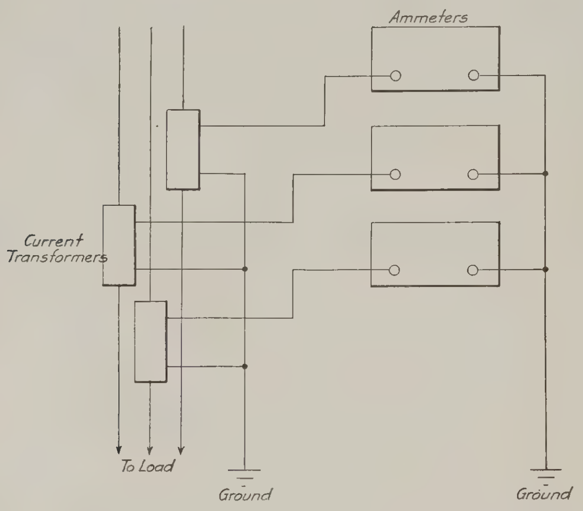


Fig. 69. Diagram Showing Three Ammeters Connected in a Three-Phase Circuit Through Three Current Transformers. With Balanced Loads Only Two Transformers Are Necessary, Connected as in Fig. 64. Two of the Ammeters are Connected in Place of the Current Coils of the Wattmeter Shown, the Third Ammeter Being Connected in the Neutral (Grounded) Secondary Return Lead.

Caution

Current transformers should always be considered as part of the line circuit and should never be handled except to make necessary changes, even then only the secondary lead should be touched.

When it is necessary to change the secondary leads for any reason, the ground connection should always first be inspected to make sure that it is intact before making the changes. If a current transformer is installed where an attendant might come in contact with it, it should be surrounded by a protective case.

Connections

The diagram shown in Figs. 63 and 64 show the two principal connections of current transformers when used with watt meters. Fig. 63 shows one current transformer used on a single phase circuit while Fig. 64 shows a three phase circuit. It should be remembered that any unbalanced three phase system would require two current transformers and two potential transformers as shown for the polyphase meter. A two phase system also requires one of each connected to each phase and may be thought of as two separate single phase circuits. The method of connecting ammeters and the number of transformers required for the different services are shown in Figs. 67, 68 and 69.

Attention is called to the fact that sometimes meters are not calibrated to indicate main line current and in such cases the meter readings should always be multiplied by the ratio of the transformers supplying the meters. For example, if a current transformer with a ratio of 160 to 1 and a potential transformer with a ratio of 20 to 1 were used with a recording watt meter, it would be necessary to multiply the watt meter readings by 160x20 or 3200 to get the correct amount of power used.

Portable Current Transformers

A portable current transformer, as the name implies, is one that can be carried from place to place for checking up branch circuit currents. The portable transformer has but one winding; namely, the secondary winding. It is constructed in such a manner that it resembles a ring which can be opened and passed over the primary line which acts as the primary winding with one turn. This induces a current into the secondary circuit which is connected with an ammeter specially designed and calibrated for this transformer.

A New Transformer Oil

Lectroseal (L. S.) oil is a new grade of insulating transformer oil recently introduced by the Westinghouse Electric & Manufacturing Company. This oil has its chief application as an insulating and cooling medium for use with all classes of oil insulated distributing and power transformers. It is also used with such apparatus as induction type feeder regulators and electrolytic lightning arresters.

Lectroseal is a pure mineral oil, obtained by the fractional distillation of petroleum, and is free from moisture, acid, alkali and sulphur compounds. As an insulating medium, it has a high dielectric strength. The average breakdown test is said to be 40,000 volts on a .15 in. gap between spheres ½ in. in diameter. As a cooling medium, it is claimed that this is particularly well adapted, the viscosity being very low (approximately 36 at 40° C., Saybolt method). Consequently, the oil will circulate rapidly and transfer the heat quickly from the transformer or other apparatus to the walls of the tank.

If water should accidentally enter a transformer tank, it should sink to the bottom of the tank as quickly as possible, as a small percentage of water thoroughly mixed with the oil reduces its dielectric strength very rapidly. Various grades of oil differ greatly as to their ability to separate from water with which they have been mechanically mixed, but Lectroseal oil, it is claimed, possesses this quality in a marked degree.

The other characteristics claimed for Lectroseal oil, such as freedom from deposit, satisfactory flash and fire point, low rate of evaporation and light color, would indicate that this is practically ideal for the purpose for which it is intended.

The Standard Underground Cable Co.

The Standard Underground Cable Company has recently opened a new branch office at 704 Wilkins Building, Washington, D. C. Mr. Edward Kerschner, formerly with the Philadelphia office, is in charge of the new office.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 52

The Stone-Franklin Car Lighting System

The Stone system of electric car lighting so extensively used in Canada, Europe and other foreign countries is now being introduced in the United States by the Franklin Railway Supply Company in its improved form, under the name of the Stone-Franklin Car Lighting System.

The fundamental principles of this new equipment are identical with those of the Stone equipment as operated abroad. New construction details have been embodied in the Stone-Franklin equipment, however, some of which were suggested by experience with approximately 70,000 equipments operating in every part of the world under widely varying conditions and others which were found necessary to adopt the new equipment to the standards of American practice.

The generator of the Stone-Franklin equipment is suspended from the car body similar to the original method of mounting all Stone equipments. The slipping belt principle of controlling the generator output, which is used with this equipment, permits the use of a generator which always operates at the speed for which it was designed, which naturally results in the generator operating under as near perfect electrical conditions as can be obtained in electric car lighting service. Due to the fact that this generator does not follow the speed of the train, the full-output speed has been raised slightly with a resulting reduction of weight and bulk with any given kw. capacity. This is easily understood from the above mentioned fact that the generator will never exceed its minimum full-output speed regardless of train speeds, and yet this generator under ordinary operating conditions is the lowest speed car lighting generator used.

Output Control

The usual way of controlling the output of an axle generator in this country is to provide an automatic mechanism that will vary the field current to compensate for the various changes in train speeds, the generator meanwhile follows the train speed in all its variations, as there is an initial high belt tension which is maintained by springs to prevent slipping. The Stone-Franklin system, however, as we have already mentioned, controls the generator output with the slipping belt principle. By this method the belt tension is obtained by allowing a portion of the weight of the machine to rest on the belt, and the amount of this tension can be varied by moving the point of dynamo suspension toward or from the driving axle by a tension screw in the suspension link which will evidently cause a greater or less proportion of the weight of the dynamo to be borne by the belt.

Output Indicator

The angular position of the machine as it hangs against the belt thus determines the amount of belt tension and therefore the generator output. This angular position is translated into terms of electrical output by an output-indicator, located on the generator terminal block. This indication enables the maintainer to adjust the belt tension for any desired output while the machine is at rest in the yards, thus making an ammeter test on the road unnecessary.

The Principle of Slipping Belt Control

When the train starts up, with a definite proportion of the dynamo weight lying in the belt, thereby causing a predetermined belt tension, the generator will quickly build up to normal voltage. After the automatic cut-in switch has closed, current will be delivered to the external circuits, lamps, batteries, etc., and the output will increase until the torque or turning effort of the armature becomes such a quantity that the belt, in endeavoring to turn the armature, will pull the machine towards the driving pulley thereby shortening the distance between pulley centers to such an extent that the belt will begin to glide or slip over the armature pulley. The armature will then continue to rotate at this predetermined speed, delivering a predetermined watt output regardless of the increase in train speed.

From the above it can readily be seen that the torque and the weight lying on the belt are the governing factors which determine the quantity of output delivered by the generator over and above a predetermined train speed. In this manner an important and probably the most interesting question of controlling the output of a generator driven from a source of variable speed is solved mechanically and permits the generation of current under correct electrical conditions insuring perfect commutation and electrical stability with all train speeds. To the uninitiated the great accuracy and reliability of this control together with the remarkable belt life obtained is most surprising. This intricate problem of controlling the output of an axle generator will be covered in detail in a future lesson. A peculiar and desirable feature of this method of regulation of the generator output provides for a charging current which tapers sufficiently to prevent destructive overcharging.

Lamp Voltage Control

With the Stone-Franklin equipment the standard battery capacity is divided into two equal parts. The chief reason for this arrangement is to eliminate the use of an electrically controlled lamp voltage regulator. When the lamps are switched on, and the generator is operating, one-half of the battery receives a charge while the other half is connected directly in parallel with the lamps and serves to stabilize the lamp voltage. The lamp current, however, is supplied from the generator through a suitable lamp resistance. As the train slows down, the two batteries will automatically take up the lamp load in parallel, and in this manner the full storage capacity is available for lighting purposes when the generator is inoperative. This feature will be fully described in one of the following paragraphs.

An automatic battery change-over switch alternates the two battery units as regards their electrical position in the system every time the train starts. This insures that a newly charged battery is always floating across the lamps with the result that the lamp voltage is kept at its constant and proper value. By means of this automatic battery change-over switch an equal state of charge of the two battery units is insured. In the daytime the switching off of the lamps short circuits the resistance and the generator charges both batteries in parallel.

Following is a complete detailed description of the fundamental principles of the Stone-Franklin car lighting system. The mechanical details and the maintenance of this equipment will be described in the future lessons.

Fundamental Principles and Theory

The essential component parts of the Stone-Franklin Car Lighting Equipment are:

A generator.
A battery divided into two equal units.
An automatic cut-in and out switch.
A lamp resistance.
A main light switch.

With these few parts electrically connected, as shown in Fig. 1, the demands of a modern car lighting system are fulfilled. In order to thoroughly understand the electrical operation of this equipment, it will perhaps be advisable to follow carefully through the schematic diagram, Fig. 1, which shows the electrical circuits in their simplest form.

When the train starts up the generator voltage builds up and at the predetermined value, usually 32 volts, the automatic cut-in and out switch closes the circuit between the generator and external circuits consisting of batteries and lamps. The current from the generator is kept in uniform direction by the specially designed pole changer indicated on the diagram by switches P—P.

When the lamp switch is in the "on" position the distribution of the generator current is as follows: A portion of the current known as the charging current for battery A flows from common positive through battery A to common negative, returning to the generator. Another portion flows from common positive through the lamp resistance to the lamps and on to common negative, returning to the generator. The introduction of the lamp resistance reduces the voltage of that portion of the generator current flowing from common positive through the lamps to the required lamp voltage.

By referring to Fig. 1 it is evident that battery B is connected directly in parallel with the lamps and in this manner the lamp voltage is kept steady, regardless of the current flowing through the lamp resistance. The fact that the lamp current, which is supplied by the generator, is reduced to the correct lamp voltage by means of the lamp resistance, makes it evident that this stabilizing or regulating battery B cannot receive a charge nor will it discharge any current during the time the generator is operative, provided battery A is fully charged. This is because the lamp resistance is so calibrated that it will allow the full lamp current to pass from the generator to the lamps, only at a time when the voltage of battery A has risen to its maximum or full-charge value of about 40 volts. When the voltage of battery A is less than 40 (indicating that it is not fully charged) part of the lamp current is furnished by the stabilizing battery B as will be explained further on. When battery A is fully charged and its voltage is up to its correct value of about 40 volts, it can readily be seen that the voltage across the lamp resistance is equal to the difference between the voltage of battery A and the lamp voltage, and when this difference of voltage is at its maximum the battery A is fully charged and at such time the full lamp current can pass from generator to lamps.

It will be understood that the charging current to battery A is a variable quantity, depending on the state of charge of this battery. As this battery nears a state of full charge, so a greater portion of the current passes through lamp resistance to the lamps due to the increase of voltage at common positive. If, however, the voltage at common positive is below 40, due to the battery not being fully charged, it is evident that the lamp voltage would be cut down correspondingly if it were not for the fact that the regulating battery B is connected immediately across the lamps and, therefore, keeps the lamp voltage constant and up to its proper value. It is also evident that any current supplied by the regulating battery B under such conditions is subtracted from the current coming from the generator to the lamps through the lamp resistance and, therefore, the voltage drop across this lamp resistance is reduced. In this way the voltage at the lamp side of the resistance is maintained constant by an automatic variation in the lamp current going through it.

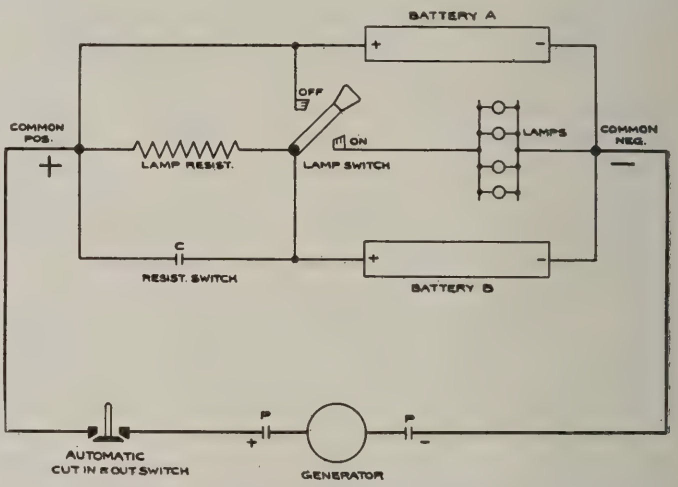


Fig. 1. Simple Schematic Diagram of Connections for Stone—Franklin Car Lighting System.

From this description it is evident that the battery A receives a decided taper charge because as the generator voltage increases, the greater is the amount of lamp current furnished by the generator, with a consequent reduction of charging current. This is further augmented by the principle of generator output control—the slipping belt, which results in constant watt output and, therefore, a reduction of charging current as the voltage increases.

It can further be seen that excellent lamp voltage must be obtained without any electrically operated lamp regulator, and any vibration on the part of the train cannot have the slightest effect on the lamp voltage since the connections are permanently fixed and no variable resistance is interposed between the lamps and the supply. Flickering of the lights is, therefore, eliminated under all conditions.

When the train stops, resistance switch at C, Fig. 1, is automatically closed and the two batteries then furnish current to the lamps in parallel and in this way the full storage capacity of both batteries is available. As a refinement of lamp voltage regulation on the actual equipment, only a portion of the lamp resistance is usually short circuited by the switch C, so that the battery, last charged and therefore at a slightly higher voltage than the regulating battery, will send current to the lamps through a very small amount of lamp resistance, which is usually called the "balancing resistance."

It is evident that the Stone-Franklin equipment can operate in any given local service with a very low generator output, due to the fact that only a comparatively small current is required to form the proper charge rate for battery A, while if both batteries were combined in a single battery of equal capacity it would be necessary that the system be equipped with a generator capable of furnishing twice the charging rate necessary with the Stone-Franklin equipment.

The actual equipment is furnished with an automatic change-over switch which alternates batteries A and B with reference to their electrical position in the system every time the train starts and in this manner a fully charged battery is always connected across the lamps, insuring constant lamp voltage at its proper value. This automatic switch further insures equal state of charge of the two batteries. This has been tested out in many instances with ampere hour readings in each battery, which at the end of long runs and after a prolonged test period have always indicated an equal state of charge of the batteries.

The switching off of the lamps automatically short circuits the lamp resistance and therefore parallels the two batteries which are then being charged as one unit. This would be shown in the diagram with the lamp switch in the "off" position.

It is, of course, understood in cases where there are numerous banks of lamps, the lamp resistance can be made up in any required portions and introduced or switched in or out of circuit as the lamps are being switched on or off. In other words, a resistance can be furnished for each lamp circuit, with the result that such a system provides for unlimited flexibility.

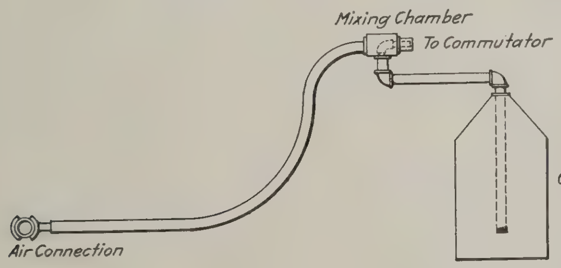
As an evidence of the close lamp regulation obtained with this system it is interesting to know the results of tests taken in this country with cars having a number of lamp circuits and individual control varying the lamp load from 57 amperes down to 7 amperes. The lamp voltage in this case did not vary more than .4 of a volt, including stopping, acceleration of train up to 80 miles an hour and stopping down, over a distance of over 300 miles during which the test was taken.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

A Compressed Air Gasolene Spray

It is often necessary to clean accumulations of dust and grease from the current carrying parts of axle light generators and for this purpose we have fitted up a compressed air and gasolene spray cleaning apparatus as shown in the accompanying sketch, for use at our Fifty-first street coach yards. This apparatus is effective and saves a lot of time in performing this work. The air hose is attached to air connections which are placed every 100 ft. on the sidewalk in the yards and the air valve is opened a little to permit some air to blow through. This creates a vacuum at the gasolene nozzle in the pipe junction which draws some gasolene from the can. The gasolene, when mixed with the air, forms a spray similar to the action of an atomizer.

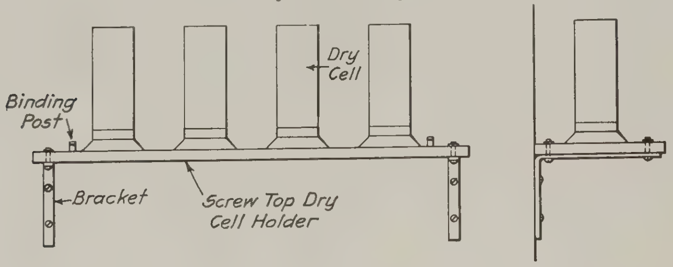


The apparatus is simple to make and inexpensive. An old water hose about 50 ft. long is fitted with an air coupler on one end. The other end is equipped with the spray mixer head illustrated in the sketch, which is simply made up by inserting a ¼-in. pipe L into a 1-in. T fitted with the proper nipples and reducer. The L is connected to the gasolene supply. The reduction of effective air pipe space at the point where the gasolene pipe nozzle ends increases the speed of the air flowing through and creates the vacuum which draws up the gasolene from the tank below.

John L. Ohman,
Electrician Foreman, Chicago & Western Indiana.

Improved Method of Mounting Screw Top Dry Cell Holder

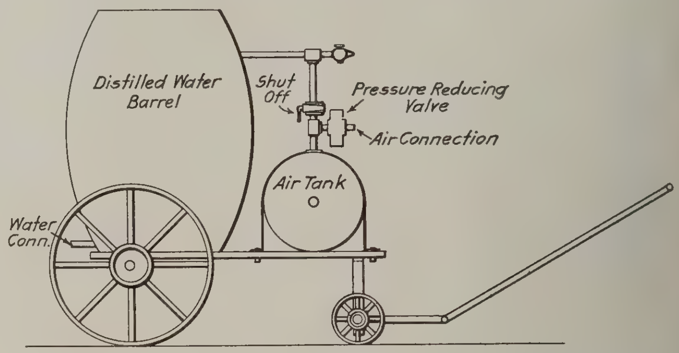
Having had considerable trouble with the Patterson screw top dry cell holder which allowed the cells to shake loose and fall out with the vibration of the car, thus weakening the bell current or putting the bells out of order, we tried the following stunt. The holder was removed, the hinges, by which they are fastened to the locker, were taken off and L-shaped brackets made of 1 by ⅛-in. iron were applied instead. When we reapplied the holder we reversed it as shown in the sketch so that the dry cells stood in it instead of being suspended as they were originally. In this way, the weight of the dry cells keeps them from working loose in their holder with the result that they are always tight. The brackets were made of such dimensions as to bring the dry cells about ½ in. from the steel locker, thus avoiding any possibility of a ground caused by a cell rubbing against the steel.



L. S. Noble,
Pullman Company, Chicago, Ill.

A Battery Flushing Outfit

The battery flushing outfit shown in the accompanying sketch is used by the Chicago & Western Indiana at the Fifty-first street coach yards. It is high enough so that about one-half of the contents of the barrel flow into the battery by gravity. After that an air pressure hose is attached to the nearest air connection in the yard and the remainder of the water is then forced out. The pressure reducing valve limits the air pressure to an amount suitable for forcing the remaining water into the battery. If it were necessary to store air under full pressure in the tank, the pressure reducing valve would be placed between the air tank and the barrel and the air hose would be connected direct to the tank.



John L. Ohman,
Electrician Foreman, Chicago & Western Indiana.

Illumination of Pullman Cars

Standardization of a New Fixture Using a 100-Watt Gas-Filled Lamp

D. Woodhead and A. L. Arenberg

Since the introduction of the vacuum tungsten filament lamp, increased attention has been given to the illumination of railway cars. Because of its high efficiency, engineers and designers immediately realized its possibilities, and a careful study was made of the requirements for a satisfactory system, both from the standpoint of the public and the company owning or operating the cars. A car lighting system in order to meet the requirements of the public must provide sufficient light, prevent eye strain, and at the same time present a pleasing appearance. In addition to the foregoing, the owning or operating company requires that a lighting system be economical to operate, economical to install, and adequate to insure the safety of passengers.

Intensity Required

In arriving at a minimum intensity of light which will provide sufficient illumination, various foot candle values have from time to time been considered. When designing a railway car lighting system operating from a 32 volt system, consideration must be given to the fact that at times the voltage on the lamps may drop as low as 28 volts; that there may be further loss in efficiency of 10 % to 15% due to dust gathering, and a decrease in output from the lamp which may be as much as 20% before it is discarded. A drop in intensity to 50% of normal would therefore occasionally occur. If it is desired to have a minimum intensity of 2½ F.C. on a 45 degree reading plane, the average horizontal intensity when the equipment is in first-class shape, and the voltage up to normal, should be approximately 7-foot candles.

Eliminating Eye Strain

Eye strain may be caused by insufficient light, heavy shadows, uneven illumination, points of high intrinsic brilliancy in the field of vision, or decided contrasts in illumination to which the eye must adapt itself.

In attempting to eliminate eye strain in car interiors, it is necessary to remove the chief causes, such as bare lamps with bright filaments placed in the field of vision, insufficient light, and extreme contrasts. It is hardly necessary to say that bare lamps should not be used except with some form of shade which will cover the bright light source to such an extent as to make it impossible to see the filament from the ordinary field of vision. This shade may be of a dense opal glass open at the bottom, or, if possible, a bowl completely inclosing the lamp. Much may be done to eliminate eye strain by mounting the car fixtures as close to the head lining as possible, thereby allowing only the distant fixtures to come within the range of vision. Extreme contrasts in intensities can be prevented to a great extent by properly distributing the light on the plane of illumination and by using a light colored finish on the interior of the car, particularly the head lining. There should be few glazed surfaces in order to avoid unpleasant glaring effects which result from specular reflection.

Appearance Considerations

From the standpoint of the public the appearance of a lighting installation governs to a considerable extent its success. Regardless of what the results may be, an installation that is unsightly or gives a depressing effect, is never a success. It is for this reason that opaque reflectors are very rarely employed in car lighting, the preference generally being towards the use of diffusing glassware in order to brighten the upper part of the car.

Maintenance Costs

In the selection of a system from the viewpoint of the car owner or operator, the cost of maintenance becomes the all important item. This expense begins immediately when the car is put in service, and continues as long as the car is in use. It is, therefore, essential that this cost be kept as low as possible in order to secure the greatest returns on the investment. The principle items affecting the cost of maintenance are lamp replacements and fixture cleaning. The use of a single unit fixture in preference to a multiple unit is by all means to be urged. The cost of one lamp of large wattage is usually less than the combined cost of several smaller lamps of an equal total wattage. In replacing lamps it is necessary to install only one lamp instead of several. The cleaning of a single unit fixture may be accomplished in proportionately less time and the breakage on glassware is greatly reduced.

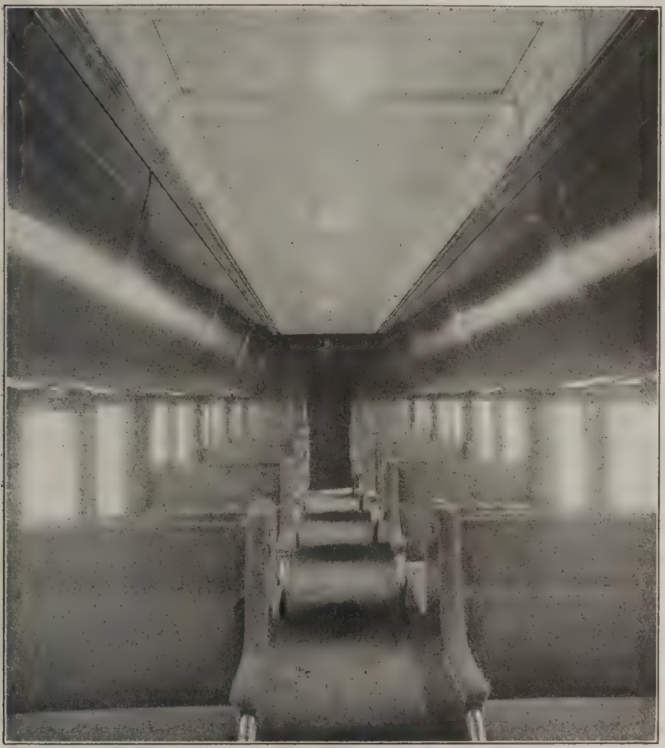


Fig. 1. Interior View of Standard Pullman Car Showing New Fixtures.

First Cost

The question of wiring is one which affects the first cost. The greater the spacing of the fixtures, and the fewer the outlets, the lower will be the installation cost; but the spacing must not be too great if uniformity of illumination and lack of shadow are to be secured. The cost of lighting units is affected by the number of holders, shades, sockets, etc., that are used, and consequently, a single unit fixture can be generally secured at a reasonable first cost.

Use of Tungsten Lamps

In considering the various ways in which the tungsten lamp may be used, it will be remembered that at first the lamps, either clear or frosted, were placed in fixtures without diffusing glassware or shades of any type. Due to the characteristic distribution of the light from a tungsten lamp a great deal of it was wasted on the dark decks and sides of the car, only a small percentage reaching the reading plane as useful illumination. The glare due to the high intrinsic brilliancy of the tungsten filament made it almost impossible for passengers to see or read with comfort, and the necessity for the use of diffusing glassware soon became apparent.

Systems

Many and various systems have been since tested and used. Perhaps the most generally used scheme has been that employing a number of fixtures spaced uniformly along the center of the car. The fixtures are of both the single unit and multiple arm types carrying two, three or four small lamps. In certain types of cars, bracket fixtures have been installed in addition to the overhead system. These are usually equipped with one or two small lamps and are put in chiefly for decorative purposes.

Use is made of diffusing glass shades of different types designed to reduce the glare from the filament and at the same time, if possible, to reflect the light in the useful angles, giving uniform illumination. Although the shapes and sizes of the shades have been juggled about considerably it has never been possible to arrive at an entirely satisfactory system from the standpoint of glare, efficiency and uniformity. The deeper types of shades screen the filament enough to sufficiently reduce the glare, but at the same time they absorb considerable light, thereby reducing the efficiency. Due to the depth of the shade most of the light is reflected beneath the fixture, leaving points of low illumination between the fixtures. Where the flare type of shades are used higher efficiency and more uniform illumination have been secured. However, the filament of the lamps being more exposed allows the light to enter the eye from three or

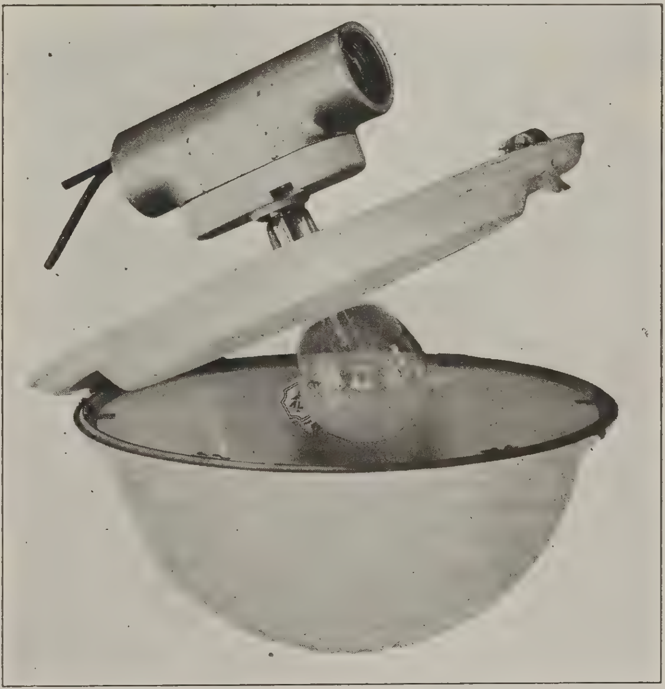


Fig. 2. Make-Up of the New Fixture Showing Relative Position of the 100-Watt Mazda C Lamp and the Condulet Socket

four fixtures at such angles as to cause considerable discomfort and fatigue.

The System Used

Realizing the limitations of the open type of shade and keeping in mind the requirements for a satisfactory system as previously outlined in this article, experiments were sometime ago started with the idea of using a hemispherical bowl of diffusing glassware enclosing a tungsten lamp at the sides and bottom and having a slightly concave reflector above to reflect the upward light back through the bowl.

With this type of unit, the lamp being entirely enclosed, there was no objectionable glare from the filament and it was a question of determining if satisfactory efficiency could be obtained without increasing the total wattage per car. However, on test it was found that when the bowl was mounted against the head lining in the center of the car, the sources were high enough to cause no eye strain; the appearance was pleasing, but the intensity at the reading plane was too low. Fixtures were then constructed which lowered the bowl about two feet, this change bringing the intensity up to an acceptable value, but the eye strain became objectionable since the light source was well down in the line of vision. Also the appearance of the car was not pleasing and there were objectionable shadows on the ceiling.

The plan of using the bowl flat against the head lining was suitable from the standpoint of eye strain and appearance, so it became a question of securing a more efficient light source.

About this time news came of the development of the 100 watt Mazda "C" gas filled lamp for 32 volt service, and as soon as samples were obtained further tests were made. The greater efficiency of the gas filled lamp brought the intensity to a very satisfactory value and efforts were then turned toward the designing of a fixture which would have a low maintenance cost as well as a low installation and first cost. As a result the fixture shown in the accompanying cuts was standardized.

Description of the New Fixture

The fixture consists of a band of either malleable iron or cast brass to which is hinged a ring of the same material carrying a 12-inch bowl of Central Electric Company's pressed Berylite diffusing glassware. The reflector immediately above the lamp is made of enameled steel and is slightly concave in form to redirect the light downward through the bowl. The hinged band is fastened upward by means of a secure catch, it being possible to readily clean the fixture by releasing this catch and swinging the bowl downward. Four long bolts are put through the roof of the car and serve to hold the fixture against the head lining.

The fixture itself, therefore, contains no sockets or electrical connections. The main train line is run just above the head lining in 1½-in. conduit. At points where the fixtures are mounted a G-5 condulet is inserted and a PE-63 porcelain receptacle cover with 6-in. leads is used. The narrow neck of the 100-watt Mazda "C" lamp projects through the opening in the reflector and screws directly into the condulet cover. The conduit is mounted at such a height above the head lining as to bring the filament of the lamp into proper focusing position for the uniform illumination of the bowl and for securing the desired distribution of light.

New and Old Systems Compared

A comparison of the new system with the old one, using a four arm fixture, shows the following points of superiority:

1. 76% more illumination is secured with no increase in power consumption as shown by the data on tests.
2. The new fixture is mounted higher and the filament of the lamps is completely covered. Eye strain is greatly reduced.
3. Those who have seen the new system in operation are quick to comment on the improved and pleasing appearance.
4. The cost of maintaining and cleaning the fixtures is enormously reduced. Instead of having to remove four lamps, clean them, dust four shades and then replace the lamps, it is now only necessary to release the bowl catch, allowing the glass to swing down, dust it out, wipe off the one lamp without removing, and again swing the bowl into position.

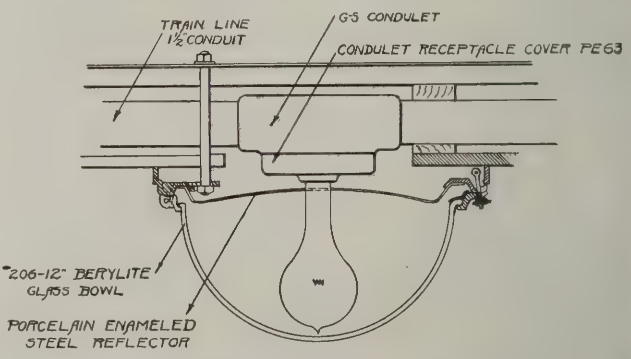

TRAIN LINE
1½" CONDUIT
G-5 CONDULET
CONDULET RECEPTACLE COVER PE63
206-12" BERYLITE GLASS BOWL
PORCELAIN ENAMELED STEEL REFLECTOR

Fig. 3. Detailed Drawing of the New Pullman Fixture Showing Application.

5. The cost of lamps is reduced 23.6%. Formerly 4/25 watt G-18½ round bulb lamps were used in each fixture. At a list of 36 cents each the total list value of lamps per fixture was $1.44. The present list of the 100-watt gas filled lamp in PS-25 bulb is $1.10.
6. The breakage on glassware during cleaning and while in service has been reduced to practically nothing.
7. The absence of sockets or electrical connections on the fixture eliminates electrical repair cost and makes it possible to readily remove the fixture at any time.
8. With the old multiple arm clusters, having four shades and shade holders, there was a greater possibility for accidental dropping of the glass than is the case with the new unit having a heavy pressed bowl securely held in a cast ring.

Photometric Tests

Extensive tests were made at various times on the different schemes tried while attempting to arrive at a satisfactory system. The results of the final tests only are given here in summarized form.

After deciding to use 12-in. bowls with 100-watt Mazda "C" lamps tests were made, equipping a car with samples of a number of the different makes of glass on the market.

Berylite glassware finished smooth inside and out was finally chosen because of its high efficiency and pleasing appearance.

Test Results

Tests were then made on a car equipped with the old four arm fixtures having a 25-watt lamp in each square shade or a total of 100 watts to the fixture. Corrected results showed an average of 4.2 ft. candles on a plane 36 in. from the floor of the car.

Another set of tests was made on the car equipped with the new unit, using 100-watt Mazda "C" lamps. The corrected results of this test showed an average of 7.4 ft. candles on a plane 36 in. from the floor. This is an increase in efficiency of 76% as compared to the old system.

During all tests the lamps were operated from storage battery and a careful check kept on the voltage. Afterward all readings were corrected to 32 volts which was the rated voltage of the lamps used.

New Gould Chemically Pure Planté Positive Plate

It is a well-known fact that the positive plate of a storage battery receives harder service and accordingly wears out faster than the negative plate. The new type of plate known as the "chemically pure" plate, very recently placed on the market by the Gould Storage Battery Company, is designed with a view toward greatly increasing the life of the positive plate and toward making it more nearly approximate that of the negative plate. This plate was developed as the result of research work in connection with submarine battery service for the U. S. government. This particular service is unusually severe on account of the heat and high discharging rates.

The manufacturers state that the process of formation of this plate is entirely different from the electro-chemical processes hitherto employed in the manufacture of Gould planté plates.

In their earlier types of plates, made according to the old formation process, it was necessary to have a very large exposed surface of the lead rib in order to produce an initial capacity up to the rating of the plate. After approximately a year's service, the active material produced in the original formation all became dislodged, due to the battery action, and was replaced by new active material formed by the pure planté action of the plates charging and discharging in sulphuric acid electrolyte. This natural planté active material is apparently in a considerably more condensed form than was the originally formed active material, as it exists in a comparatively thin layer over the surface of the plate. This new active material has considerably more capacity per pound than the original active material. This accounts for the usual increase in the capacity of planté plates after about one year of service.

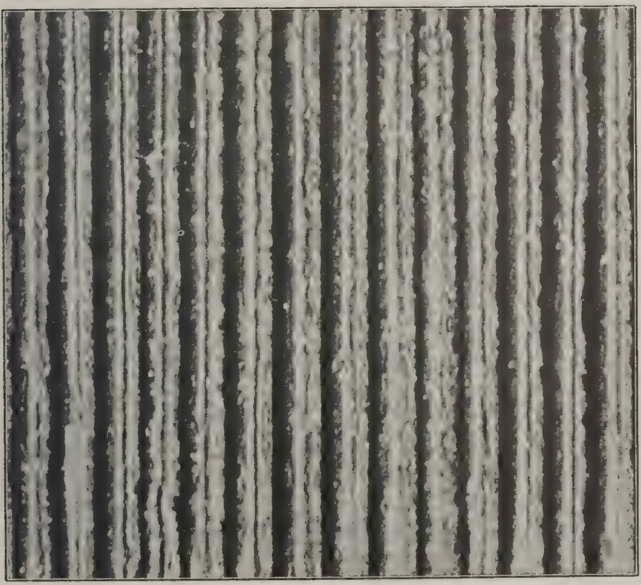


Fig. 1. Magnified Section (five diameters) of the Surface of the New Gould Positive Plate. Note the Space Between Ribs and Also the Crystalline Structure of the Plate as Shown by the Tiny White Dots.

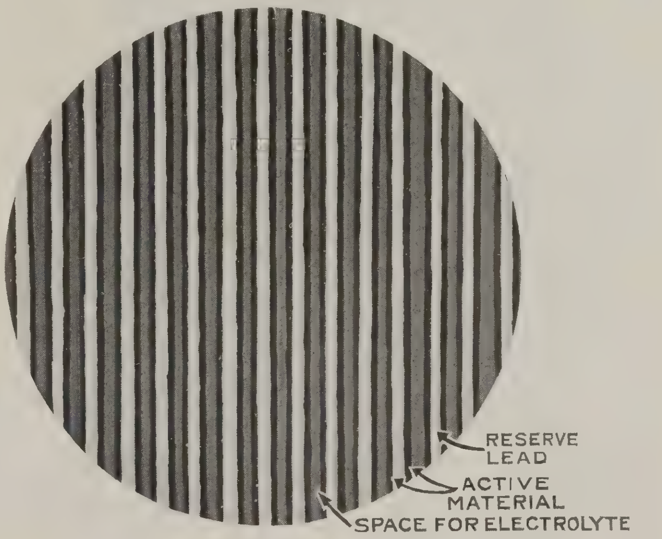


Fig. 2. Showing the Relative Thickness of Reserve Lead, Active Material, and Space Between Ribs. This View Was Made by Filling a Plate with Sealing Wax and Then Planing It Off Carefully. The White is Reserve Lead, the Black is Active Material and the Gray is Space Between Ribs.

The new chemically pure planté positive was designed with a view toward obtaining, if possible, the pure planté active material in a highly condensed form in the initial process of plate manufacture. The chemically pure active material of the new plate, having a higher capacity per square inch surface than the old electro-chemically formed plate, now makes it possible to obtain normal battery capacity with a smaller plate surface than formerly. This permits of the use of heavier ribs and wider acid space between ribs. Where formerly the plates were made with .0020-in. ribs and .0016-in. space, the new plates are made with .0024-in. ribs and .0024-in. space, which evidently provides more reserve lead and a wider space between ribs for quick and easy diffusion of electrolyte.

As a result of this new type of formation there are apparently two distinct advantages obtained. First, there is a somewhat heavier section of reserve lead in the ribs of the plate which is made use of for future conversion to peroxide—(when there is no more reserve lead left in the ribs of a plate, the battery is about at the end of its life). Therefore, the more reserve lead provided, the longer will be the battery life. The second advantage is found in that the active material being formed in a thin but very dense skin over the surface of the ribs, the grooves between ribs are left open clear to the bottom, permitting of free circulation of electrolyte. This should remove one of the chief causes of battery sulphation, that due to highly concentrated acid becoming pocketed in the depths of the plate, as may sometimes occur where the active material is formed to such a thickness as to completely fill the space between ribs. Moreover, as the wider spacing of the new plate allows a free circulation of the electrolyte, the diffusion of the acid out of the active material on charge and into it again on discharge will be very materially assisted. Accordingly, the battery gives a somewhat higher voltage on discharge and reaches a full state of charge at a slightly lower voltage than is experienced with the older type of plate.

Another important advantage with the new plate is that even if it may become badly sulphated, the active material never completely fills the space between the ribs and accordingly cannot set up expansion strains that cause buckling of the plate.

The mechanical features of the new plate are also of considerable interest, for the ribs, being considerably heavier than in the older plates, will stiffen it materially and tend to prevent buckling. Moreover, since the space between ribs is considerably wider than in the former type of plate and with the active material existing in the form of a very thin skin, there will be much more space allowed for the expansion of the active material when it becomes sulphated. The result of this is that even if the active material may become badly sulphated, there is ample room provided for the consequent swelling of the active material. This cannot set up expansion strains in the plate itself, for it is these expansive strains, due to the fact that there was not sufficient room for the active material to expand on sulphation, that caused buckling in the earlier type of plates.

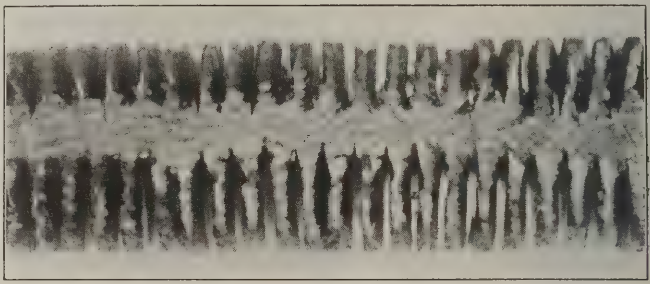


Fig. 3. End of the Positive Plate Sawed Off to Show Space Between Ribs. View is Taken Looking Lengthwise Through an Eight-Inch Plate.

No forming acids whatever are used in the plate manufacture, therefore there will be no impurities introduced into the battery from this source, and excessive formation of the plates in service will be eliminated. The active material of the new plates is pure lead peroxide in a crystalline form.

Personal Mention

E. T. Sawyer

E. T. Sawyer, who has been associated with the Commercial Acetylene Railway Light and Signal Company for over eight years, has resigned to accept a position as sales engineer with the Edison Storage Battery Company. Mr. Sawyer, from about 1901 to 1904, was with the western office of the Dressel Railway Lamp Works of New York and the Star Brass Manufacturing Company of Boston. He later spent four years in the employ of the Acme Ball Bearing Company as manager of the railway department. His first three years in the employ of the Commercial Acetylene Railway Light and Signal Company were spent as southern manager. For the last five years he has been connected with the main office at New York.

C. S. Schroeder

C. S. Schroeder, treasurer of the Schroeder Headlight Company, Evansville, Ind., was killed in the railroad accident at New Decatur, Ala., on Saturday, May 6. Mr. Schroeder entered the headlight business with his father at an early age and when 21 years old took over the management of the company. From a small plating works in 1885, the company has developed into a large manufacturer of electric and oil headlights. Mr. Schroeder was active in business until the time of his death.

F. L. Gilman

F. L. Gilman, who was formerly assistant general superintendent of the Hawthorne works of the Western Electric Company, has been transferred to the engineering department with the title of assistant chief engineer. The above change became effective April 10, 1916.

Mr. Gilman, who was graduated at Harvard in 1895, has been identified with telephone interests for 21 years. He is a fellow of the American Institute of Electrical Engineers, a member of the American Society of Mechanical Engineers and a charter member of both the Harvard Engineering Society of New York.

General News Section

Improved Consolidated Axle Light Panel

The ampere hour meter control of the Consolidated Axle Light Equipments which has given such satisfactory results in reducing the cost of operation of car lighting equipments, has been still further improved by the Consolidated Company, so that the same meter that controls the battery charging current from the car lighting generator and discontinues the current to the storage batteries when the batteries have become fully charged is now employed for the additional purpose of controlling the current supplied to the car while being charged from an outside source, as, for example, when standing in the railroad yards.

It has been found that when cars are charged while standing in the yards from the yard service mains, that the storage batteries are very frequently overcharged by reason of the car being left on charge for too long a period.

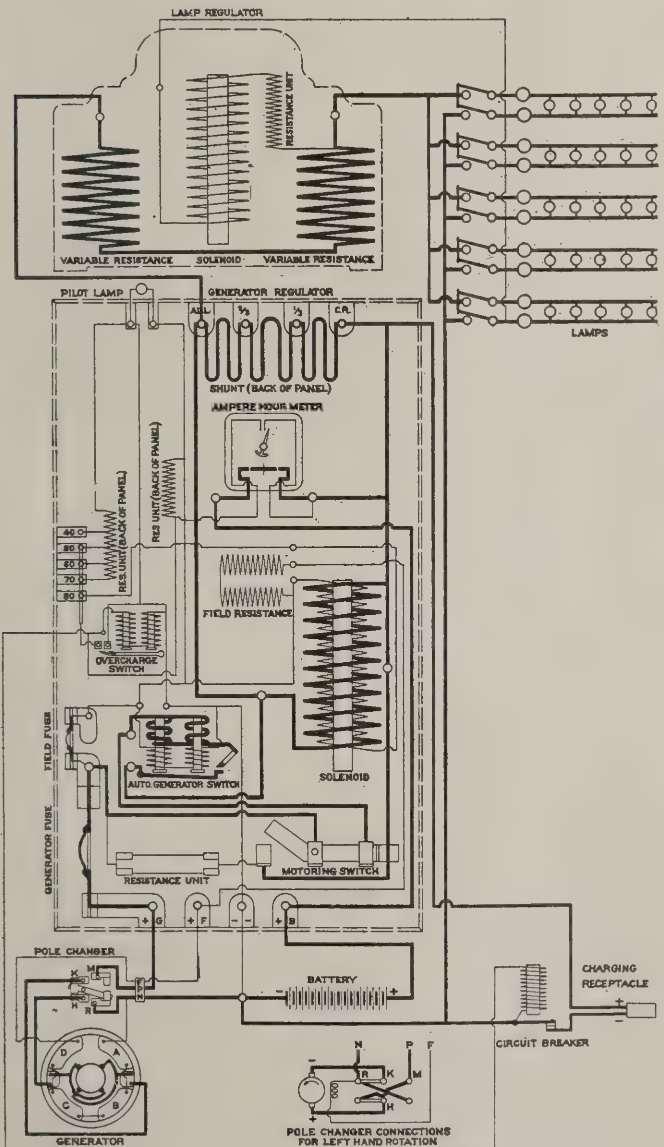


Fig. 1. Connection Diagram for Improved Consolidated Axle Light Panels.

By a slight change in the arrangement of the circuits of the Consolidated Axle Light System, the ampere hour meter is caused to register the amount of charging that the battery receives from the yard plant, and by the arrangement shown in the wiring diagram herewith, when the meter registers "full charge" of the battery, the contact switch is closed by the meter hand, which causes the circuit breaker to operate and disconnect the charging mains from the battery so that the battery will receive no further charge.

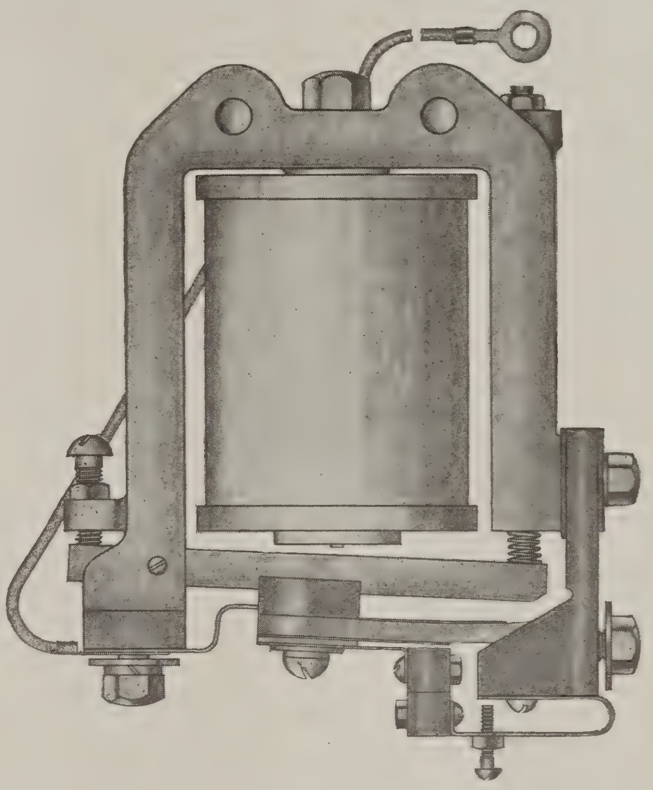


Fig. 2. Circuit Breaker Used With Improved Consolidated Panels for Opening Outside Charging Receptacle Circuit When Battery Is Fully Charged.

The Norma Company of America

The Norma Company of America—manufacturers of "NORMA" high-precision anti-friction bearings—announces through its president, Mr. W. M. Nones, the purchase of a ten-acre factory site at Elmhurst, on the outskirts of Long Island City. The property fronts on Queens Boulevard and has a depth of about a thousand feet, abutting in the rear upon the main line of the Long Island Railroad, from which a siding will be built directly into the plant.

The company has, in five years, become prominently identified with the automobile industry of the country. Beginning as importers of bearings, the merit of its product gained quick recognition among the manufacturers of ball-bearing automobile accessories. Today "NORMA" bearings are the standards in most of the high-grade magnetos, lighting generators and starting motors made in America. The steadily increasing demand for these high-speed, silent-running bearings—soon outstripping import resources—forced the company into the manufacturing field and has necessitated repeated enlargements to its factory facilities.

The latest move is made in response to an imperative demand for a still larger immediate output, with facilities for extension with the future growth of the business.

The plans now under way provide for a four-story building, 70x350 feet, to be erected immediately in reinforced concrete. Every modern improvement will be embodied, looking toward the maximum of production efficiency. The architects for the new factory are Francisco & Jacobus of New York City. The location was determined upon, not alone for the unsurpassed shipping facilities afforded, but also for its ready access to the labor markets and home sections grouped around Long Island City—surface and subway lines running close to the property, giving quick communication with neighboring Long Island towns as well as with Manhattan Island via the Queensboro Bridge.

Westinghouse Electric & Manufacturing Company

The annual report of the Westinghouse Electric & Manufacturing Company for the fiscal year ended March 31, 1916, shows that the sales billed and the net income for the year were in excess of those in any previous year in the history of the company. The gross earnings totaled $50,269,240, as compared with $33,671,485 in 1915 and $43,733,646 in 1914. The net manufacturing profits for 1916, after the deduction of cost of sales and cost of manufacture, including depreciation of property and plant and all selling, administrations and general expenses, were $9,429,896 as compared with only $2,562,000 in 1915. The company's net income for the year was $9,666,789 as against $2,900,744 in 1915 and $4,058,809 in 1914. The surplus at the close of the fiscal year was $9,246,707 as compared with $7,473,412 on March 31, 1915.

The splendid showing evidenced in the report was largely due to orders for war munitions, the shipments on account of which amounted to $8,578,266. The company is obtaining a share of domestic prosperity, however, for the value of orders received during the year exclusive of orders for war munitions was $58,218,171, and the value of unfilled orders as of March 31, 1916, for the regular products of the company was $22,097,995 as compared with $5,464,000 (of which $3,486,445 was for war munitions) at the same date in 1915. The amount of war munition work that is being done in the main works at East Pittsburgh is small and has not materially interfered with the output of the regular products of the company. The total orders for war munitions booked by the company, its proprietary companies and the Westinghouse Machine Company amount to approximately $96,527,000. A large part of this is included in the contracts for the manufacture of 1,800,000 army rifles which are now being manufactured by the recently incorporated New England Westinghouse Company at its factories in Springfield, Chicopee Falls and East Springfield, Mass. No shipments have yet been made on this contract, and no income has been received from this source. The advance cash payments, amounting to $12,037,500, received on account of the rifle contract, have been paid over to the New England Company. This amount and the assets and liabilities of the New England Company are not included in the parent company's balance sheet given herewith in brief:

ASSETS	
Property and plant	$21,201,305
Sinking fund	706
Investments	15,662,752
Current assets, including $7,797,676 cash	21,864,587
Working and trading assets	18,850,947
Other assets	4,852,649
Total	$82,432,946
LIABILITIES	
Preferred stock	$3,998,700
Common stock	52,644,800
Funded debt	3,283,000
Collateral and long term notes	2,816,250
Real estate purchase money mortgage	210,000
Current liabilities	9,470,826
Reserve	762,662
Profit and loss—Surplus	9,246,707
Total	$82,432,946

The Western Electric Company

Bigger, better business coupled with the tendency of the electrical industry to center uptown has resulted in a new location for the Western Electric Company's retail store in New York City. In its new quarters, in the Tilden Building, 105 West Fortieth street, the store is situated but a stone's throw from Broadway, and is in the heart of a rapidly growing commercial section.

Because of more commodious quarters, a larger assortment of electrical goods will be carried at the new location. A complete line of electrical supplies, both staples and specialties, is carried in stock.

Trade Publications

The Ampere Hour Meter:—The Sangamo Electric Company has recently had prepared a small pamphlet on "Recent Improvements in the Construction of Ampere our Meters." The subject matter is a reprint of the A. B. C. Car Lighting lesson appearing in the *Railway Electrical Engineer* for March and April, 1916. These pamphlets will be furnished upon request to the Sangamo Electric Company, Springfield, Illinois.

X-Ray Flood Lighting.—A pamphlet recently published by the National X-Ray Reflector Company of 235 West Jackson Boulevard, Chicago, and 21 West Forty-sixth street, New York, contains some interesting and instructive information and data regarding the use of the projector units manufactured by this company in the illumination of smokestacks, signs, buildings, etc., by flood lighting. Some unique illustrations showing the effect of this method of lighting are given together with complete engineering data necessary for designing a lighting installation of this kind. This pamphlet may be obtained from the National X-Ray Reflector Company on request.

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WE GUARANTEE, that of this issue 2,500 copies were printed; that of these 2,500 copies, 1,809 were mailed to regular paid subscribers, 159 were mailed to advertisers, exchanges and correspondents, and 532 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 15,300, an average of 2,176 copies a month.

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Volume 7. JULY, 1916 Number 14.

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Distilled Water for Battery Flushing

The collection of scale or sediment on the inside of boiler tubes is somewhat typical of one of the results of not using pure distilled water for battery flushing. In the operation of the steam boiler only pure distilled water goes off as steam, the impurities being left behind; similarly, in the operation of a storage battery, only pure distilled water, or its equivalent in hydrogen and oxygen gases, is given off by evaporation and by gasing on overcharge. Here, again, as in the case of the steam boiler, all impurities which existed in the water which was used for flushing the storage battery are left behind in the electrolyte of the battery. If battery flushing with impure water is continued these impurities in the flushing water gradually pile up in the electrolyte until they soon exist in such quantity that they may seriously injure the battery plates.

Battery operation in the past has required that the batteries be cleaned every year or eighteen months and at this cleaning period, where impure water has been used for flushing, it has usually been necessary to throw away the entire supply of electrolyte in the battery tanks, replacing it with new.

With the present high price of sulphuric acid this waste becomes an item of considerable importance in battery maintenance, but where pure distilled water is always employed for flushing the storage batteries, it has been found that the electrolyte in over 95 per cent of the cells can be saved and used over again after the battery is cleaned. This feature alone, entirely aside from the reduction in battery plate diseases, such as are caused by impurities in the flushing water, would easily warrant the general practice of using distilled water for flushing car lighting batteries.

Anti-Friction Bearings in Axle Generator Service

While it is generally conceded that the use of anti-friction bearings in axle generators insures more reliable operation under all conditions of service than could be expected or was obtained with the various types of sleeve bearings used formerly, the actual results obtained on several of the larger railroads, which prove the superiority of the anti-friction bearings, give us some important and instructive information on this interetsing and important subject. For this reason, the comments of H. C. Meloy of the New York Central, of E. S. M. MacNab of the Canadian Pacific and of A. E. Voigt of the Atchison, Topeka & Santa Fe, which are given on page 408 of this issue, and the article by J. R. Sloan of the Pennsylvania, also appearing in this issue, are of interest.

A study of Mr. Voigt's letter shows that during the years 1913, 1914 and 1915 there were an average of 201 anti-friction bearing axle generators and an average of 651 sleeve bearing axle generators in service. During the three years there were a total of seven anti-friction bearing failures and 50 sleeve bearing failures, which means that although there were approximately three times as many generators equipped with sleeve bearings as there were equipped with anti-friction bearings, the failures were in favor of the machine equipped with the anti-friction bearings in the ratio of 1 to 7. The comparison of the operation of the two types of bearings is in reality more favorable to the anti-friction bearings than the figures indicate, because, of the seven anti-friction bearing failures, only one was due to a broken ball, while six were due to broken or loose lock nuts, caused, no doubt, by improper application. On the other hand, each of the 50 sleeve bearing failures was the result of some inherent fault of that type of bearing.

The effect of anti-friction bearings on the Pennsylvania's unit maintenance cost per generator is clearly shown in the curves in Fig. 1, appearing in Mr. Sloan's article. These curves show that the unit maintenance cost per generator was reduced in approximately the same proportion as the number of sleeve bearing generators were reduced until a constant minimum value of net generator cost per car month was reached. Mr. Sloan's article also brings out the fact that out of a total of 734 equipment years, there have been but four ball bearing failures reported. It would seem that in view of the success of the anti-friction bearing in axle generator service, the use of such bearings in shop motors would be equally successful in improving their reliability and decreasing their maintenance cost.

Letters to the Editor

Anti-Friction Bearings in Car Lighting Generators

CLEVELAND, Ohio.

TO THE EDITOR:

It is safe to assume that with an average of 250 ball bearing equipments in service for two and one-half years there has not been one single failure due directly to the bearings. There have been a few cases where the bearings were not properly greased or a failure due to some neglect. I do know that previous to the changing from sleeve bearing to ball bearing that we were constantly having hot bearings, allowing the armature to get down upon the pole pieces, which necessitated the rewinding of the armatures and in some cases the rewinding of the fields as well as the renewal of bearing. Of course, you are aware that if it was possible to keep oil on the sleeve bearing this trouble would not occur, but the service being such that the cars remained away from the regular inspection terminals for a considerable period of time, the bearings and oil slingers become worn, or when not properly applied the oil slops out to such an extent that it is necessary to refill the oil wells at main terminals, that is, a car in Chicago and New York service would have to be oiled at both ends of the run, or else there would be danger of a hot bearing.

With the application of the ball bearing all this trouble has been eliminated and should a car get out of regular line there is no danger of hot bearings.

H. C. MELOY,
Engr. Electrical Appliances, N. Y. Lines West.

MONTREAL, Canada

TO THE EDITOR:

We have had 22 equipments in service since 1909, and to my knowledge we have only had a couple of actual failures due to ball bearings. Several were, however, renewed in the shop, as when inspected they were found to be slightly loose. There is no question in my mind as to the absolute advantage of the ball bearing over the sleeve bearing, especially in this climate where we get such variation of temperature.

E. S. M. MACNAB,
Car Lighting Engineer, Canadian Pacific.

TOPEKA, Kan.

TO THE EDITOR:

During the year 1913 we had 15 ball bearing equipments and 707 sleeve bearing equipments. We had no ball bearing failures, but had 24 sleeve bearing failures, as follows:

19 due to worn bearings.
3 due to worn bearings, account no oil.
2 due to chain oiler on narrow slot bearing.

During the year 1914 we had 246 ball bearing equipments and 671 sleeve bearing equipments. We had 3 ball bearing failures, as follows:

1 due to broken ball,
2 due to loose lock nuts,

and 14 sleeve bearing failures, as follows:

9 due to worn bearings.
3 due to oil ring broken.
2 due to worn bearings, account no oil.

During the year 1915 we had 343 ball bearing equipments and 574 sleeve bearing equipments. We had 4 ball bearing failures due to loose lock nuts, and 12 sleeve bearing failures, as follows:

8 due to worn bearings.
1 due to worn bearing, account no oil.
2 due to broken oil rings.
1 due to oil box cover broken, binding oil ring.

A. E. VOIGT,
Assistant Electrical Engineer, Santa Fe.

A Comment on Mr. Lunn's Paper

NEW YORK CITY.

TO THE EDITOR:

Reading through your valuable June issue I was particularly interested in Mr. Lunn's paper on "Maintenance of Lead Storage Batteries in Car Lighting Service." No doubt a great deal of saving in battery maintenance cost would be effected if such a method would be universally adopted and furthermore such a system would show more clearly the splendid progress the art of car lighting has made in recent years, since light failures would no doubt be still further reduced and the quality of light greatly increased.

From a practical point of view, however, it seems to me that this system as outlined by Mr. Lunn could be modified somewhat, in order to effect better economy. Mr. Lunn recommends to switch on the full lamp load and if the voltage is found to be unexplainably low, volt meter readings of every cell should be made. Here it seems to me that if the batteries are put on a fairly heavy discharge representing about a six-hour rate, any small defect in the cell could be detected at an early stage of its development and thereby considerable labor could be saved. If the maintenance man switches on full lamp load as Mr. Lunn recommends, which, particularly in a Pullman car, would mean the operation of all subsidiary switches, in order to get even a ten-hour discharge rate on the batteries, a considerable amount of time would be taken up and defects in the very early stages would hardly be noticed at such a rate.

It seems to me, therefore, that if the maintenance man was furnished with a portable resistance which could be connected to the charging receptacle on the car, the battery could be put on a discharge of any desired rate at a moment's notice. The maintenance man would then be able to detect any defect in the battery in its very early stages. If voltage readings were then taken periodically, together with gravity readings, and the generator output adjusted according to the requirements indicated by these readings, terminal charging of batteries would practically be eliminated.

H. D. ROHMAN,
Chief Electrical Engineer, Franklin Railway Supply Co.

Anti-Friction Bearings in Axle Generator Service

J. R. Sloan

THERE are probably few mechanical or electrical engineers who fully appreciate the severe service conditions under which railway axle lighting generators must operate. This service is particularly severe as regards the mechanical features of the axle generator, namely, the belt and bearings. Whether the equipment be mounted on the car truck or suspended from the car body, belt operation is a somewhat difficult matter. With the truck mounted type, the short distance between centers of the driving axle and the generator shaft requires a high initial belt teision in order to pull the load; and on the body hung suspension, the change in alinement due to the swing of the truck in rounding curves has a tendency to greatly decrease belt mileages.

Particularly with the truck mounted type generators, the high initial belt tension necessary to prevent belt slipping, and this being oftentimes applied by careless inspectors far in excess of the amount actually required, causes very severe loads on the pulley end bearing. In addition to the bearing strains due to belt pull, we have sometimes severe stresses set up due to the vibration and lash of the truck at curves, frogs and crossings. These features coupled with the difficulties of inspection and maintenance en route were undoubtedly the chief causes of some excessively high generator maintenance costs experienced during 1911 and 1912 as shown below.

TABLE OF AXLE GENERATOR MAINTENANCE AND REPAIR COSTS, SHOWING REDUCTION IN UNIT COST WITH INTRODUCTION OF ANTIFRICTION BEARINGS.

	1911	1912	1913	1914	1915
Total axle generators in service (December).	260	289	321	320	323
Number sleeve bearing generators in service (December)	260	211	175	115	18
Number axle generators equipped with ball bearings (December)	0	78	146	205	305
Total expense for inspection, maintenance, etc., on axle generators alone	$54,899.42	$79,277.14	$65,205.44	$51,464.83	$60,508.41
Cost of remodeling generators for ball bearings	......	5,378.00	13,841.68	13,132.18	18,387.28
Net total cost for generators, inspection, and maintenance....	$54,899.42	$73,899.14	$51,363.76	$38,332.65	$42,121.13
Net generator cost per car per month......	$23.30	$24.12	$14.57	$10.22	$10.86

Reducing Maintenance Costs with Anti-Friction Bearings

There is no question but that the rather extensive application of anti-friction bearings made during the past three years has been the means of saving the day for the axle generator. From an examination of the accompanying table it will be noted that in 1911 there were 260 axle generators in service and all of these were equipped with sleeve bearings. During the following years, 1912, 1913, 1914, 1915, some new equipments mounted on ball bearings were added and some of the old generators were remodeled and equipped with ball bearings. The net result of this was that the number of sleeve bearing generators in use decreased from 260 in 1911 to 18 in 1915.

The total expense items include all labor, material and store house expenses in connection with axle generators. Notwithstanding this, however, the maintenance costs per car per month as given at the bottom of the table are excessively high during 1911 and 1912. This was undoubtedly due to the fact that with the sleeve bearing generators it was necessary to motor and oil each generator every day in order to be sure the generator was in good condition; in addition to this the generator was given a complete overhauling every month.

Maintenance—Anti-Friction Bearing Generators

With axle generators equipped with anti-friction bearings, however, the daily inspection consists simply of feeling the generator to see if it is warm when it arrives in the yard and also making sure that the belt is in good condition. This takes but a very small fraction of the time formerly required for inspection and maintenance. These ball bearing mounted generators are given a general overhauling once in nine months and at this time the grease is renewed in the ball bearings. The generators are motored now only once a week instead of daily when mounted on sleeve bearings.

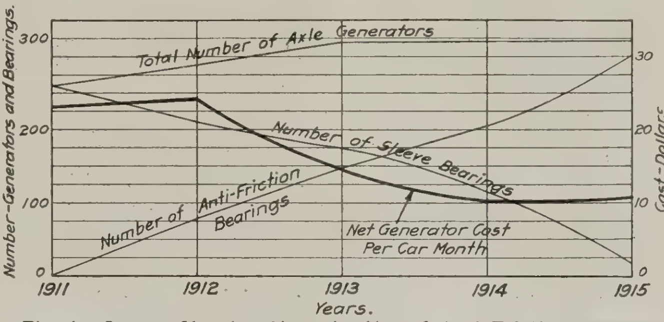

Fig. 1. Curves Showing How the Use of Anti-Friction Bearings in Axle Generators on the Pennsylvania Reduced the Unit Maintenance Cost Per Generator.

Without a doubt the reduction in generator inspection and maintenance expense from $24.12 in 1912 to $10.86 in 1915 has been largely, if not entirely, brought about by the use of ball bearings. The slight reduction in cost in 1914 below that of 1915 was probably due to the fact that during that year passenger traffic was very light and many of the cars were out of service. In 1915, however, passenger traffic was about normal.

Ball Bearing Failures

Of the total 734 equipment years there have been but four ball bearing failures reported, or approximately but ½ of 1 per cent per annum. This is an extremely good showing in comparison with the frequent failures of plain bearings in this service.

Of these four failures, two were due to improper mounting, in one case the bearing seat being too loose and in the other case too tight, resulting in a worn shaft and loose bearing in the first case and a cracked inner race in the second; the two other failures were due to ball failures. In no case, however, was the armature or field coils damaged, a frequent occurrence when sleeve bearings failed and let the armature down on the pole pieces.

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* Engr. Electric Car Lighting, P. R. R.

Semi-Annual Convention

Association of Railway Electrical Engineers, Atlantic City, N. J., June 16, 1916

THE convention, held in the Hotel Dennis, was called to order by the president, E. W. Jansen, and the report of the secretary-treasurer was read and accepted. The association then heard the reports of the various standing committees.

Committee Reports

The first report considered was that of the Committee on Illumination, which is published on page 351 of the June issue of the *Railway Electrical Engineer*. Because of the limited time at the disposal of the association, L. S. Billau, chairman (B. & O.) simply gave an impromptu abstract of the report.

The report of the Sub-Committee on the Rating of Train Lighting Lamps was included in Mr. Billau's report and was received with much interest. This report as a whole dealt with the proposed change in the rating of train lighting lamps from a mean horizontal to the mean spherical or the lumen basis, and also with the question of adopting the gas filled lamps for train lighting service. Embodied in the report were revised train lighting lamp schedules based on the mean spherical candle power and lumen rating and including the sizes of gas filled lamps that the committee thought would be most desirable. The replies to a circular letter on the subject, indicated that out of a total of 9,343 cars voting, 8,584 were in favor of changing the rating of train lighting lamps from a mean horizontal to a mean spherical basis, and out of 8,585 cars voting, 6,802 were in favor of using the gas filled lamp for train lighting at an increase in initial cost.

President Jansen said that, in connection with this new rating, he thought alal the members desired to work on the lumen basis, but that a hard time will be experienced in getting away from the watt basis, but that the change could undoubtedly be made in time. He spoke of a suggestion that had been made to him by W. J. Bohan, mechanical engineer of the Northern Pacific, that the total watts of the lamps be given on the label in addition to the total lumen rating so that the label would show the voltage, the total lumens and the total watts of the lamp in question. He said that the advantages of having this information on the label would be that people not familiar with the lumen rating would gradually become accustomed to it without being confused, and that, in addition, the current consumption of the lamp could readily be calculated without referring to the efficiency in lumens per watt, usually given only in the handbooks.

President Jansen also pointed out that the 100-watt Mazda C lamps recently adopted by the Pullman Company had resulted in some complaints being made that the new lamps were too bright and that they make considerable contrast with the other cars on which equipments are owned by the Pullman Company and maintained by the railroad company. He said that he had taken this matter up with Ernest Lunn, chief electrician of the Pullman Company who advised that although they had already adopted the 100-watt lamp they were not altogether sure that it was not too large and that they had considered going to the 60-watt Mazda C lamp instead.

J. A. Andreucetti, of the Chicago & North Western, said that he had also noticed that the 100-watt lamp, as used by the Pullman Company, was too bright.

L. S. Billau, of the Baltimore & Ohio, said, in reference to the rating of the lamp as given on the label, it was felt that any changes made at this time would have to be made gradually. He said that the lamp manufacturers not only have large stocks of labels on hand, but there is a question whether the label giving both watts and lumens would not be so large as to be objectionable. He felt that this feature would have to be worked out gradually in the future.

In regard to the 100-watt Mazda C lamp also entered as 1,500 lumens, as used by the Pullman Company, Mr. Billau said that the 1,000-lumen lamp, which is shown in the new table, was suggested for the reason that there had been some complaint that the 1,500-lumen lamp was too strong in certain installations. He said that the present 75-watt vacuum type lamp, which gives 815 lumens, was considered, but the committee felt that in order to preserve the basis in multiples of 25 it would be better to increase the rating of this lamp to 1,000 lumens, which would be suitable for use in installations where the 1,500-lumen lamp would give too much light, and also this lamp could be used where the 75 or 60-watt lamp has been used in the past.

C. H. Quinn, chief electrical engineer of the Norfolk & Western, wished to know if the lumen rating would be given in the commercial catalogues which are furnished by the manufacturers, or if the new rating is to be a special feature concerning train lighting lamps only.

W. I. Rolison, of the Westinghouse Lamp Company, said that he believed the lamp manufacturers are perfectly willing to meet the wishes of the association in lamp rating and that they will try to meet anything that the committee wishes to recommend in the line of labels as far as manufacturing conditions will permit.

Mr. Porter, of the Edison Lamp Works, said that his company is already showing in some of their catalogues the lumen rating, especially in the illumination section, he also said that they would be very glad to show practically any ratings which the association desires.

President Jansen then inquired if there was any reason why the voltage and total watts and total lumens should not all be shown in the catalogue and in reply Mr. Porter said that he did not see any reason why they could not and that they will be shown in the catalogue.

Mr. Billau said that this matter had to come up in the discussion at the last conference with the representatives of the lamp manufacturers and that it is the intention in the new train lighting schedule to recommend asking that the actual total lumens of the lamp be given and also the nominal rating as expressed in watts. The efficiency will be expressed in lumens per watts instead of watts per candle as previously.

K. R. Hare of the *Railway Electrical Engineer,* when referring to the double rating on the labels, suggested that the lumen rating be given ahead of the watt rating, the former to be printed in larger type so that it would be considered the main rating. In that way those using the lamps would easily get into the habit of using the lumen rating.

Mr. Billau then stated that as this part of the committee's work was practically completed, the committee would be glad to have a vote from the association with reference to the report of the Sub-Committee on Rating of Train Lighting Lamps so that the committee will be in a position to advise the manufacturers of what the association wants to do.

Prominent in the A. R. E. E. Left to right: H. C. Meloy, Engineer Electrical Appliances, New York Central, Lines West; E. W. Jansen, Electrical Engineer, Illinois Central, and President Association of Railway Electrical Engineers; E. Wanamaker, Electrical Engineer, Rock Island, and Vice-President Association of Railway Electrical Engineers.

After some discussion Mr. Andreucetti moved that the report of the Committee on Illumination be accepted and that the portion of the report referring to the changes in the rating of train lighting lamps be sent to letter ballot for approval. The motion was seconded and carried.

Shop Practice

Sub-Committee on Compressed Air and its Application. J. E. Gardner, who is chairman of the sub-committee, was not present so that H. C. Meloy, who is a member of the general committee, presented the report. The report was accepted without discussion.

Sub-Committee on Electric Welding

The report was submitted by Mr. Meloy, chairman, who pointed out the different headings under which the report is divided and asked for further suggestions.

Mr. Biliau suggested that the committee cover in its report a list in some suitable form of the various uses to which electric welding has been put in the railroad field. He thought that inasmuch as the use of electric welding has been extended much further in some places than in others it might be of considerable interest to get an idea of how many uses have been made of electric arc welding.

J. R. Sloan, of the Pennsylvania, suggested that a wiring diagram be shown so that the operations of the various systems can be studied.

D. J. Cartwright, of the Lehigh Valley, pointed out that there was considerable difference of opinion in regard to the protective shoe used in electric welding, especially in regard to the quality and color of the glass used and he suggested that any information on that subject that the committee could present would be of benefit to the operators of arc welding equipment.

Mr. Quinn, of the Norfolk & Western, referred to the second item under Standardization of Operation, "amount of current consumed on different operations," and suggested that consideration be given to the subject of kilowatt hours per pound of metal applied which would give the amount of energy delivered at the arc welding machine instead of the electrode.

J. L. Minick, of the Pennsylvania, pointed out that it might be advisable to study the actual conditions under which the work is done, whether scale or slag or other insulating elements of that kind would make it necessary to use a considerably larger amount of current in one case than in another where the insulating material was not present. Mr. Quinn said that what he had in mind when making these suggestions was to determine the economy of getting one large machine to supply four or five circuits, thereby charging the loss of a circuit against the weld, compared with putting a smaller machine right at the job. He also thought that the committee might find something of value in making a recommendation as to the correct size, capacity and location of the electric welding machines. He said that he had in mind one particular instance where considerable economy was effected by grouping the work near the source of power instead of running long feeders from the power house with the resulting loss in 200 or 300 feet of wire. He pointed out that this phase of the work is especially important where current is purchased.

J. H. Bryan, of the Westinghouse Electric & Manufacturing Company, suggested that it might be well for the committee to include in its report, if possible, data on maintenance cost, comparing the operating and maintenance cost of different types of machines.

Mr. Quinn suggested that the committee investigate the subject of butt welding with alternating current which he considered one of the most interesting features of electric welding. He said that recent advances in the high-speed tool-steel market have made it desirable to butt weld a small piece of tungsten steel, probably two inches thick, on an ordinary piece of tool steel; he pointed out that considering the present price of tungsten steel considerable economy can be effected in this way. He also suggested that the committee look into the matter of face-ending of locomotive boiler tubes by this method. The report was accepted as a progress report without further discussion.

Sub-Committee on Maintenance and Repairs

Due to the absence of J. H. Wickman the report of the Sub-Committee on Maintenance and Repairs, which was printed in the June issue of the *Railway Electrical Engineer,* was read by Mr. Meloy.

President Jansen said that the last paragraph in regard to the testing of railroad meters is especially important; he said that his road had recently gone into the subject and it was their experience that where a railroad is purchasing most of its power in towns where the power company does not have a competent meter man, it is advisable for the railroad company to test their own meters. The report was accepted as a progress report.

Anti-Friction Bearings for Motor Equipment

In the absence of C. J. Causland the report was submitted by Edward Wray of the *Railway Electrical Engineer.*

Mr. Quinn suggested that some important information relative to anti-friction bearings could undoubtedly be obtained from the people who are designing, operating and following up the use of ball bearings on mine locomotives. He said that conditions around a great many mine tipples are similar to the railroad roundhouses and coal yards where a good many of the present motor troubles occur. He thought that by coming in contact with the mine locomotive people a vast amount of valuable information could be obtained, showing the application, size and general maintenance features, the dependability and desirability of anti-friction bearings, together with some information on the size of bearings that can be applied to standard motors. The report was accepted as a progress report.

Crane, Turntable and Transfer Table Motors

The report, which is given in full in the June issue of the *Railway Electrical Engineer,* was presented by H. C. Meloy, chairman, (N. Y. C.) After reading the Committee report Mr. Meloy said that in a meeting with Chas. Robbins, chairman of the Standard Specifications Committee of the Electric Power Club, the question came up relative to inviting the steel mill engineers to co-operate with their committee. He thought that it would be advisable that both associations meet together as in that way it might be possible to work out satisfactory standards covering the entire field, with fewer type of motors. Mr. Meloy said that, subject to the approval of the Association, he had agreed to proceed along those lines.

W. H. Patterson, of the Westinghouse Electric & Manufacturing Company, suggested that the crane manufacturers be included in addition to the steel men; he said that the steel men have an association of iron and steel electrical engineers.

In referring to the second paragraph of the report on temperature rating, Mr. Patterson said he did not believe that the association of Railway Electrical Engineers desires to change the standards of the American Institute of Electrical Engineers. He felt it to be the function of the latter association to standardize time temperature ratings for motors. The committee recommends a 50 degree rise where the institute standard is 55, and for motors having fireproof insulation 75 degrees. For this reason Mr. Patterson thought the temperature rise for enclosed type motors should be 55 degrees.

Mr. Andreucetti suggested that when any reference is made to standardization rules already covered by the American Institute of Electrical Engineers, that those rules be adopted by the Association of Railway Electrical Engineers. He said that the association has membership on the Standardization Committee of the A. I. E. E. and any standards that may be necessary for work in railroad service should be referred to the Standardization Committee for adoption first.

Mr. Patterson then called attention to paragraph three which states that the torque rating on starting should be from seven to ten times the full load torque; he said that no manufacturers, to his knowledge, today handled motors which would meet with such specifications and further that such conditions would be very seldom met with.

Mr. Wray, of the *Railway Electrical Engineer,* at this point mentioned that vehicle type motors and other motors of a similar nature are now being rated on a torque basis. He said a manufacturer of electric motors for vehicles is not interested in the horsepower but does desire a motor which gives a certain maximum torque and said that it was the intention of the committee to add the torque rating with the idea of making the specification a little more definite.

E. Wanamaker, of the Chicago, Rock Island & Pacific, pointed out that the general problem of procuring the proper rating of motors in railroad service has been somewhat neglected; he mentioned especially the rating of turntable and crane motors which are only required to give their maximum torque intermittently. He said that it was with the idea to go further into the details of motor specifications of this class of work that the committee was appointed; heretofore these motors have been given a blanket rating and the intention is now to try and arrive at some conclusion as to what should be the proper basis for motor specifications. The report was accepted as a progress report.

Data and Information

The report of this committee as published in the June issue of the *Railway Electrical Engineer* was presented by Edward Wray. After reading the report Mr. Wray distributed the blank which is to be sent out to the railroads and asked for criticisms and suggestions.

Mr. Billau suggested that the committee get the blank out to the railroads as early as consistent; he said that it is generally found that by the time the blanks go through the various channels the time remaining is very short and that it is evident the more time available for the preparation of this information the better.

Mr. Minick spoke of the difficulty in attempting to arrive at a conclusion when making an inquiry into the opinions of the railroads. It said that he had tried to determine this opinion on the basis of the number of railroads voting, on the number of cars owned and several other ways; he said that one difficulty was that the data and information lists of the association, which are used to determine the number of cars owned by the railroads, have not been corrected as to the number of cars actually owned and operated since 1910; further that some of the railroads have no rating at all. He, therefore, suggested that the committee give this subject serious consideration when it comes to taking a letter ballot and that a correct list of electrically lighted equipment be prepared. Mr. Minick also brought up the question as to how the ballot should be determined, on basis of cars operated, or cars owned. He stated that the train lighting lamps are based on the number of cars owned and not on the number of cars operated. It was the opinion of the president that such letter ballot should be on the basis of cars owned.

Mr. Quinn suggested that in item 10 of the Information and Data sheet something be incorporated to determine whether the magnets are operated from shop power or isolated plants when determining the cost of maintenance. Mr. Minick called the attention to the item "shop and station equipment" on page 3. He said that under "lamps," tradenames are used. While it is true that practically 90 per cent of the lamps sold are sold under the tradename some of them are not. He suggested that in printing these blanks next year the same practice as the association has used in preparing its specifications be employed by using the term "tungsten filament" lamps and in case of the so-called type C lamps make it "gas filled" lamps. The president advised that this procedure would be followed in the future. The report of the committee was accepted.

From Left to Right—C. H. Quinn, Chief Electrical Engineer of the Norfolk & Western, L. S. Billau, Asst. Electrical Engineer, Baltimore & Ohio, and Jos. A. Andreucetti, General Foreman, Chicago & Northwestern and Secy.-Treas. of the A. R. E. E. in Front of Young's Million Dollar Pier at Atlantic City, N. J.

Train Lighting Equipment and Practices

The progress report of the committee on this subject was presented by Mr. Cartwright. A complete report was published in the June issue of the *Railway Electrical Engineer*. Mr. Sloan, who is chairman of the Sub-Committee on Wiring, read their recommendation to the M. C. B. association. This recommendation was included in the report of the M. C. B. committee on train lighting which is given elsewhere in this issue.

Mr. Cartwright said that the recommendation of the Sub-Committee on Wiring had been incorporated as part of the report of the Train Lighting Committee of the Master Car Builders' Association and would be submitted to letter ballot. He felt that the 1915 revised rules of the National Board of Fire Underwriters did not apply to car wiring, they applying to cars electrically propelled only.

Mr. Minick inquired whether comparison was made between the proposed rule and the rules being worked up and proposed by the Bureau of Standards; he said they go into car wiring to considerable detail. Mr. Cartwright said that the proposed rules of the Bureau of Standards would entail a considerable expense on the part of the railroads and an unnecessary expense in the wiring of passenger cars. Due to the low voltage of car lighting systems, the fire risk is comparatively small and for that reason the committee desires simply to give a few simple rules that will provide ample protection. He further said that Mr. Davis, the chairman of the M. C. B. Committee on Train Lighting, is at the present time handling a proposition in connection with the proposed national code rules as part of the car wiring specification, and he has tried to bring about a differentiation between cars electrically propelled and cars operated by steam and electrically lighted. The progress report was accepted.

Mr. Bliss of the U. S. Light & Heat Corporation stated what had taken place, insofar as the various manufacturers themselves are concerned, in the standardization of axle lighting equipment. Mr. Bliss said that the various manufacturers of axle lighting generators had met in an informal manner on one or two occasions for the purpose of drafting a set of specifications for axle generators. He said that they had submitted a tentative proposition of that kind to the M. C. B. Committee on Train Lighting, and that the manufacturers, at the suggestion of the joint committee, had held a meeting at Chicago last winter, at which time they went into this matter very carefully. While unofficial, it may be of interest to the association to know that the manufacturers have succeeded in getting very nearly together and progress has been made in drafting uniform specifications. Mr. Bliss pointed out that this work has become necessary, due to the fact that there is no such thing as uniform specifications in existence at the present time for car lighting generators nor can the association be guided or depend upon such a specification for rating of electrical machines as adopted by the A. I. E. E. He said that he did not think the American Institute has ever recognized the axle generator as being in existence and that many members of that society, while learned in other branches, are not familiar with the conditions surrounding the design and operation of axle generators. Mr. Bliss said that the two questions that were submitted by the joint committee meeting were the rating of axle generators and the standardization of pulleys and bearings for generators having pulleys less than 8 in. in diameter. Mr. Bliss then read a letter bearing on this subject which shows what progress was made in standardizing car lighting generator specifications.

Niagara Falls, N. Y., February 24, 1916.

Mr. J. H. Davis,
Elec. Eng., B. & O. R. R. Co.,
Chairman, Train Lighting and Equipment Committee,
Master Car Builders' Assn.,
Baltimore, Md.

Dear Sir: In conformity with the action taken at the joint meeting of the M. C. B. Train Lighting and Equipment Committee, and representatives of axle light manufacturers held at Chicago, February 3, 1916, and in response to a circular letter written by you under date of February 7, 1916, to each of said representatives, confirming such action, a meeting of said representatives was held at 30 Church street, New York City, February 18, 1916, at which the undersigned were present.

This meeting considered the two subjects referred to in your letter, viz:

(A) Rating of Axle Generators.
(B) Standardization of Pulleys and Bearings for Generators using armature pulleys less than 8 in. in diameter.

Under the subject (A), Rating of Axle Generators, the meeting discussed the items enumerated by you, and decided to recommend for your consideration, as follows:

An initial air gap of 3/32 of an inch for plain bearing machines and 1/16 of an inch for ball-bearing machines is recommended with the permissible decrease to .085 in. on plain bearing machines and .050 in. on ball-bearing machines to compensate for wear on tools and bearings, air gap to be measured by means of a suitably designed shim.

(1) Temperature rise to be measured by thermometers as specified by the A. I. E. E., page 1962, Standardization Rules, Sections 317 and 345.

(2) Temperature rise in any part of the generator after the test to be described later, shall not exceed 65 deg. C.

The ambient temperature shall not be greater than 40 deg. C. nor less than 20 deg. C. See Section 305, page 1958, and Section 320, page 1960.

No correction shall be made in the observed temperature rise due to variation in ambient temperature, as recommended by the A. I. E. E., page 1950, Standardization Rules, Section 320.

(3) Test shall be conducted with hand hole covers removed, and air draughts shall be avoided as far as reasonably practicable. Section 800, page 2008, Standardization Rules.

The standard rated voltage shall be, for so-called 30-volt generators, 40 volts.

(4) The test for determining whether or not a given generator meets the conditions of a given kilowatt rating shall be as follows:

The generator shall be connected with its regulator or regulating panel in normal operating manner, except that no storage battery, lamps, lamp regulator or lamp resistances shall be used.

A fixed resistance, equal in ohms to the quotient obtained by dividing the rated volts by the rated amperes, shall be connected across the terminals of the system (generator and regulator constitute the system) at the points where the lamp load would ordinarily be connected. This resistance shall be preferably made of a resistance metal having a zero or nearly zero temperature coefficient and be kept at constant temperature preferably by placing in a barrel through which running water flows.

The generator shall be driven at such a speed that the rated volts shall appear at the terminals of the system and fixed resistance and the rated amperes shall flow through the fixed resistance. (The resistance of the exterior connecting wires, cables and their connections, through which the rated current flows may be regarded as constituting a portion of the fixed resistance. No allowance, however, shall be made for resistance or drop in any of the apparatus itself.)

At the end of one hour the speed shall be noted and recorded and this speed shall be designated as "Rated Speed at which Generator Carried Load." (The object of this one hour run is to heat the generator rapidly and thus obviate the necessity of an inconveniently long test.)

The speed of the generator shall then be increased 50 per cent and the field current shall be adjusted, if necessary, either by hand or automatically, so that the rated volts and amperes obtain as before. (In the case of free speed generators the increased speed shall be measured on the armature shaft.) In the case of slipping belt or controlled speed generators, the increased speed shall be measured on the driving shaft, it being understood that but one belt connects the armature pulley and a pulley on said driving shaft.)

This increased speed shall be called "The Normal Speed of the Generator," as it represents very nearly the average speed at which an axle generator operates in practical service.

The normal speed, rated volts and rated amperes shall be maintained constant for three (3) hours, at the end of which time temperatures shall be taken, observing the usual precautions.

During this test the generator field current may be adjusted automatically or by hand, to maintain the normal speed, rated volts and rated amperes constant. In the case of slipping belt or controlled speed generators, the tension on the belt may be adjusted automatically or by hand to maintain the normal speed, rated volts and rated amperes constant.

If the rise in temperature of no part of the generator exceeds 65 deg. C., the generator shall be declared to be of a rating not less than that under which the test was made and at the "Normal Speed."

The name plate of generator, in addition to such other information as the manufacturer may wish to incorporate, shall be stamped with the volts, amperes and r.p.m., these quantities being the rated volts, rated amperes and rated speed as above determined.

Under the subject (B), Standardization of Pulleys and Bearings for Generators using armature pulleys less than 8 in. in diameter, the meeting discussed the question of ball bearings for so-called light weight, high speed generators, and pulleys and pulley fits. It was the consensus of opinion that there are not at the present time sufficient data from which any recommendations can be made on the following:

(1) As to the dimensions and taper of pulley fits, design of hub, and diameter of pulley for generator pulleys used with axle equipments when pulley diameters of less than 8 in. are required.

From Left to Right—H. C. Meloy, Engr. Elec. Appl. N. Y. C., Lines West; Alex McGary, Chief Elec. N. Y. C., Lines East; E. W. Jansen, Elec. Engr. Ill. Cent., J. A. Andreucetti, Secy.-Treas. A. R. E. E. and Gen'l Fm'n. C. & N. W., and E. Wanamaker, Elec. Engr. Rock Island.

(2) As to the adoption of a size of ball bearing to be used with the equipment where it is desired to use a smaller size than the No. 412.

No statistics on the number of equipments of any particular manufacture were discussed.

It was the consensus of opinion that more time must be allowed for the development of the so-called high speed, light weight generator before recommendations affecting design and construction can be presented to your committee by the manufacturers.

The letter was signed by W. L. Bliss, recording for T. L. Mount, Third Vice-President, Consolidated Railway Electric Lighting & Equipment Co.; W. F. Bouche, Supt. Electrical Dept., Gould Storage Battery Co.; G. E. Hulse, Chief Engineer, Safety Car Heating & Lighting Co.; J. L. Woodbridge, Chief Engineer, Electric Storage Battery Co.; H. D. Rohman, Chief Electrical Engineer, Franklin Ry. Supply Co.; W. L. Bliss, Chief Engineer, U. S. Light & Heat Corporation.

In closing his report Mr. Bliss said that there is so much diversion in the specifications of the various railroads that it is impossible to standardize apparatus under them. He said uniformity is an impossibility because the specifications do not produce the same apparatus with the same nominal rating.

Cost Keeping for Railroad Shop Power

E. Wanamaker, electrical engineer of the Rock Island, presented his paper on the "Method of Cost Keeping for Railroad Shop Power" which is published in full in the June issue of the *Railway Electrical Engineer*. This paper was also presented at the Master Mechanics association convention as one of their reports. In discussing his paper, Mr. Wanamaker said that on his own road they had gone to considerable expense to find out exactly where they stood on the matter of shop power cost, and that the results show that their efforts were entirely justified. He said that in some cases where they used to figure that the cost of pumping water was 2½ cents per thousand gallons, it was found the cost was as high as 11 cents. In many similar instances it was found economical to buy electric current from the local power companies and put in an automatic motor driven pump that the station agents could inspect once or twice in 24 hours and that the traveling electrician could visit once or twice a month. He laid stress on the fact that it pays to find out what operating costs amount to. Mr. Wanamaker's definition of an efficiency engineer was that he is simply a business man who has time to find out where he is at. He said that they were able to save, on the Rock Island, with very little effort, $100,000.00 and that it did not require very much effort or hard work to do it. He also said that a man was perfectly safe in jumping into most any of the railroad power plants and guaranteeing 40 or 50 per cent reduction in the cost of operation, but to do this suitable testing apparatus, including flow meters and indicators, must be available and used.

Maintenance of Electric Storage Batteries

In the absence of Ernest Lunn, chief electrician of the Pullman Company, his paper on the "Maintenance of Lead Storage Batteries in Car Lighting Service" which was published in the June issue of the *Railway Electrical Engineer*, was read by K. R. Hare.

Mr. Meloy, of the New York Central, said that he had been following the plans suggested by Mr. Lunn and had had equally good success. He pointed out, however, that by adopting the system outlined in Mr. Lunn's paper, the specific gravity readings would have to be given up and he thought it would be a mistake to do so. He said on the New York Central they make it a practice of taking the gravity of three cells as well as the voltage on discharge of all cells. He said that they not only take the specific gravity reading to keep a check on the gravity of the acids, but when taking these readings they often detect leaky tanks. He said that it would be possible when taking voltage readings alone on discharge to get a perfect reading on a tank with a low electrolyte and for this reason he thought the specific gravity reading should be taken in addition.

Mr. Sloan stated that they had been using that system of voltage inspection on the Pennsylvania since 1897 with excellent results. Mr. Hare stated that when he went with the Northern Pacific in 1912 he found the system of taking individual voltage readings of cells on discharge, a standard practice for checking up faulty batteries and that this system is still being used on that road with perfect success. Mr. Lunn's paper was accepted as read and he was extended a vote of thanks by the association.

Exhibits of Interest to Electrical Men

THE following exhibits at the Atlantic City conventions of the Master Car Builders' and Master Mechanics' associations are of interest to the railroad electrical men:

Buda-Ross Company, of Chicago, Ill., exhibited an arc headlight with an 18-in. case and reflector, also a 16-in. unit with incandescent lamp equipment. The company was represented by Mark A. Ross and J. P. Bayley.

Chicago Pneumatic Tool Company, of Chicago, Ill., exhibited numerous electric-operated tools and with the present tendency to replace air-operated tools with electric tools this part of its exhibit was of special interest. The company was represented by W. O. Duntley, W. B. Seelig, C. F. Walker, W. P. Pressinger, Thomas Aldcorn, Charles Booth, J. G. Campbell, G. A. Barden, E. M. Zwing, W. J. Devlin, B. H. Tripp, A. M. Brown, T. G. Smallwood and W. F. Delaney.

Consolidated Railway Electric Lighting & Equipment Company, of New York, exhibited their new body-hung type axle generator, the details of which will be published in an early issue of the *Railway Electrical Engineer*. A complete operating exhibit of their car lighting system demonstrated the operation of the ampere hour meter in controlling battery charging and showed the various emergency features of the Consolidated system which are designed to prevent the meter from getting out of step with the battery. Both Edison and lead batteries were shown in connection with the equipment which operated with either type as desired. The company was represented by J. L. Watson, H. I. Ryer, W. R. Hungerford, Thos. L. Mount and D. N. Balderston.

Edison Storage Battery Company, of Orange, N. J., exhibited a standard steel Pullman battery box with a complete Edison train lighting battery, of the A-8-H-type, installed. One-quarter of the battery box was empty, this feature illustrating the saving in space effected by the Edison battery.

It also exhibited an assembly of all types of trays for battery trucks, industrial and shop trucks, battery layouts and all of the various types of assemblies for railway car lighting.

Two large display boards which showed the details of battery manufacture from the beginning to the end were among the interesting exhibits. These were illuminated by a large storage battery searchlight unit which this company is just placing on the market as an emergency light for wrecks, railroad construction, etc.

The company was represented by "Battery Bill," H. G. Thompson, F. V. McGinness, H. M. Roberts, E. T. Sawyer, A. R. Hildebrant and W. F. Bauer.

Electric Storage Battery Company, of Philadelphia, Pa., exhibited its new 3 kw. body-hung axle generator, also a new 3 kw. truck mounted type generator, the former of which will be described in an early issue of the *Railway Electrical Engineer*. A new type of battery crate with open space at the sides, bottom and between the two tanks of the tray was on exhibit. This unit is a modification of that described on page 295 of the February, 1915, issue of the *Railway Electrical Engineer*.

A new type of wooden separator was also exhibited, this having a heavy section where the separator rests on the bottom support.

A new signal battery of two cells per unit in a portable shape was shown. This has the same vent hole construction as starting and lighting batteries which have been so successful in automobile service.

An operating exhibit of its car lighting equipment with complete control panel was shown.

This company was represented by J. Lester Woodbridge, F. G. Beetem, G. H. Groce, Charles W. Bell and H. E. Hunt.

Elwell-Parker Electric Company, of New York, exhibited a new elevating platform truck of the type known as "EC." With this truck it is possible to run the platform under a load and quickly load the truck by simply raising the platform. On unloading the platform is simply lowered. It also exhibited an industrial truck and a crane truck. The company was represented by L. C. Brown, G. W. Brown, M. S. Towson, Jos. M. Brown, Frank B. Ward, J. W. Emery, J. W. Cain, E. G. Jackson and S. G. Elbe.

Fairbanks, Morse & Co., of Chicago, Ill., exhibited their new ball bearing type electric motors of 50 hp. capacity and smaller. The special insulation treatment of the motor was also shown, also the internal type starter known as the "CC." The company was represented by A. A. Taylor, C. T. Fugitt, K. P. Brown, George Howard, J. L. Jones and M. O. Southworth.

Franklin Railway Supply Company, of New York, exhibited the new Stone-Franklin car lighting system in addition to its regular line of mechanical specialties. This system is being described in the A. B. C. Car Lighting Course of the current issue. A completely assembled generator, properly mounted, was shown in addition to a supply of detailed parts to show the construction of the machine. A regulating panel, complete, as installed in the car, was also on exhibit. The company was represented by J. S. Coffin, Sr., Samuel G. Allen, Walter H. Coyle, Ralph G. Coburn, C. W. Floyd Coffin, J. S. Coffin, Jr., Henry D. Rohman and Harry M. Evans.

General Electric Company, of Schenectady, N. Y., had an interesting exhibit of its arc-welding equipment behind the middle screen, into which were fitted numerous colored glass windows permitting all visitors to see exactly how arc welding is done, without injury to their eyes. Various kinds of welds were made. They also exhibited a complete line of lamps and a new double-spindle shaper, directly connected to an 8,000 r. p. m. motor, the speed of which could be adjusted at will by a controller. This shaper illustrated the great advantage of electric motor drive in that the smaller space occupied was three by four feet as compared with four by sixteen feet as commonly required by the belt-driven shaper.

Various starting panels and starting switches with protective plugs and night switches with lock-out switch, emergency switches, contractors, etc., were shown.

A 25-hp., 230-volt reversing motor panel for cleaners was shown operating with push-button control. In addition a complete line of motors and motor accessories was exhibited.

The company was represented by W. O. Kellogg, C. H. Williams, J. A. Boers, L. T. Blaisdell, W. J. Clark, P. A. Dyer, F. S. Hartman, R. E. Moore, C. C. Pierce, E. F. Lawrence, R. S. Bennett, C. Fair, R. E. Woolley, W. L. Merrill, J. W. Ham, J. A. Seede, D. K. Frost, H. L. Unland, C. D. Knight and L. W. Shugg.

Goff Electro Pneumatic Brake Company, of Pittsburgh, Pa., exhibited an electro pneumatic brake appliance for steam and electric cars. An air storage tank is provided on each car, which is charged from the air train line; an electrically operated valve controlled by the locomotive engineer sets the brakes on all cars simultaneously, thereby eliminating the surging of the cars as the flat is taken up due to uneven brake application. The company was represented by M. D. Hays, Frank Goff, Howard Goff and Thomas Joiner.

Gould Storage Battery Company, of New York, exhibited its new type of positive plate for storage batteries known as the chemically pure plate. This plate was described in the June, 1916, issue of the *Railway Electrical Engineer.* It also exhibited a new body-hung type axle-generator suspension for accommodating its standard low speed generator and also its new high speed generator especially designed for body mounting. An operating exhibit demonstrated the characteristics of the car lighting system. The company was represented by F. P. Huntley, G. G. Milne, C. E. Rood, G. R. Berger, P. H. Simpson, W. F. Richards, W. H. Sauvage, G. B. Young, M. R. Shedd and W. F. Bouche.

Johns-Manville Company, H. W., of New York, exhibited a complete line of electric material, including lighting fixtures, friction tape, "No-Arc" fuses, line material, etc. The company was represented by J. E. Meek, J. C. Younglove, G. A. Nichol, P. C. Jacobs, F. J. Horne and H. G. Newman.

Kerite Insulated Wire & Cable Company, of New York, had their usually attractive reception booth in which samples of Kerite wires and cables were exhibited. The company was represented by Azel Ames, P. W. Miller, J. A. Renton and J. W. Young.

Lincoln Electric Company, of Cleveland, Ohio, exhibited its variable voltage arc welding equipment and an operating welder showed the characteristics of the machine. Actual demonstrations of welding flues, building up worn motion parts, broken frame repairs, etc., were executed in the exhibit booth. With its new type of equipment no resistance is necessary in the arc circuit, as the welding equipment is so designed as to give a constant heat over the operating range of the unit—in other words, the product of current times voltage is always constant. The motor generator welding set was mounted on ball bearings. The company was represented by Robt. E. Kinkead and Dorsey C. Anderson.

Mechanical Specialty Company, of Chicago, Ill., exhibited an interesting display of MB type wrenches, nippers and pipe tongs. The latter were of especial interest to electrical men because of the ease with which conduit can be screwed into space in very confined quarters. The tongs bear on two-thirds of the circumference of the pipe and the work can be installed where a wrench action of only 10 degrees is possible. The company was represented by George R. Law.

Okonite Company, of New York, exhibited Okonite insulated wires and cables of every type suitable for every electrical service, also Okonite splicing and Manson friction tape. The company was represented by Lewis G. Martin, J. D. Underhill, W. T. Kyle and F. J. White.

Pyle-National Company, of Chicago, Ill., exhibited its new 2½-kw. turbo-generator set suitable for lighting a suburban train of ten cars in addition to the electric headlight. It also exhibited a 1,500-watt, a 300-watt and a 150-watt, 6 volt turbo-generator set, each with a standard arc headlight and incandescent headlight case. A full line of headlight accessories, repair parts, etc., were also shown. The company was represented by William Miller, C. E. Miller, C. P. McGinnis, O. W. Young, R. L. McIntosh, R. C. Vilas and J. Will Johnson.

Pyrene Manufacturing Company, of New York, gave some interesting demonstrations as to how readily Pyrene fire extinguishers will put out a heavy electric arc. The company was represented by E. L. Kent, Benjamin D. Trask, H. B. Vandegrift, W. H. Yetman and William Dorry.

Reliance Electric & Engineering Company, of Cleveland, Ohio, exhibited both direct and alternating current control apparatus for variable speed motors. A motor equipped with Hyatt roller bearings and in which all internal parts were exposed was also on exhibit. Another interesting feature of their exhibit was the demonstration of variable speed motor range from 400 to 1,600 r. p. m. obtained by shifting the armature laterally in the field frame. Push-button control with motor operation of the armature shifting makes it possible to adjust the speed of the motor from any point in the shop. The motor was belted to a generator so that it was demonstrated under full load operating conditions. The company was represented by C. L. Collens, H. M. Hitchcock, A. M. MacCutcheon, C. A. Beck and J. Z. Kelly.

Views of Car Lighting Belt of Safety "Under-Frame" Equipment in Operation. Left—Rounding a Ten Degree Curve, 35 m. p. h. Right—Rounding a 27 Degree Curve, 45 m. p. h.

Safety Car Heating & Lighting Company, of New York, had a very interesting exhibit of an "underframe" generator with its suspension mounted on a swinging truck frame so that the complete generator with suspension could be swung through an angle to correspond with the swing of the car as it rounds a curve in actual service on the road. The axle generator was driven at all various train speeds in the various positions corresponding to certain degrees of track curvature. In this matter the operation of the axle generator belt on rounding curves was very clearly observed, as shown in the illustrations. The view at the right shows the generator swung to the extreme position which would correspond to rounding a 27-degree curve and the equipment is here operating at a speed corresponding to 35 miles per hour. In the view at the left the equipment is swung to a degree corresponding to a 10-degree curve and the generator is operating at a speed of 45 miles per hour. A small model of the generator suspension was exhibited which demonstrated that the belt tension maintained by the device is almost exactly constant throughout a wide swing of the generator, which might be caused either by the belt stretching or by a change in the distance between centers on rounding a curve.

A large assortment of car lighting fixtures of the various types and the Safety Car Fan were also on exhibit. The company was represented by R. M. Dixon, W. L. Conwell, J. A. Dixon, A. C. Moore, W. L. Garland, G. E. Hulse, J. S. Henry, C. B. Adams, G. H. Chadwell, L. Schepmoes, J. H. Rodger and W. I. Thomson.

Schroeder Headlight Company, Inc., of Evansville, Ind., exhibited its new 2½-kw. electric turbo-generator suitable for lighting eight or ten suburban cars in addition to the electric headlight locomotive cab lights. It also exhibited its standard sizes of headlight units. A special feature of the exhibit was the adjustable focusing stand for use in the old type headlight cases, making it possible to bring the concentrated filament of the new type incandescent lamp to the exact focus center of the headlight. The company was represented by J. Henry Schroeder.

U. S. Light & Heat Corporation, of Niagara Falls, N. Y., exhibited their standard axle generator equipment and an operating exhibit demonstrated the behavior of the system under all sorts of operating conditions of varying loads, varying speeds and varying conditions of battery charge, etc. U. S. L. storage batteries for car lighting and for signaling were exhibited both in the complete assembled form and in disassembled parts, showing the details of battery construction. A full set of axle generator parts showing the construction of the generator were also exhibited. The company was represented by J. Allan Smith, A. H. Ackermann, C. C. Bradford, H. A. Matthews, E. F. Oates, W. L. Bliss, W. A. Turbayne and L. S. Cunny.

Westinghouse Electric & Manufacturing Co., of East Pittsburgh, Pa., occupied their attractive reception booth adjacent to the ballroom as usual. Although they did not exhibit any equipment, the electric welding of high speed steel on the tip of cutting tools was demonstrated. This feature is described in another part of this issue. As a special feature of the convention, this company had leased a moving picture theatre adjacent to the convention hall and there showed a complete series of "movies" taken on all of the various Westinghouse railroad electrifications. These pictures demonstrated the operation of electric locomotives under actual service conditions and was most interesting and instructive.

The company was represented by R. J. Ross, H. C. Mode, R. L. McLellan, J. W. Crowley, J. H. Bryan, W. H. Patterson and H. W. Beaumont.

Westinghouse Lamp Company, of New York, occupied an elaborate reception booth adjacent to the main ballroom, where a complete installation of high candlepower Mazdas was installed to give an added illumination in the entire Westinghouse booth. A complete assortment of various lamp sizes was also shown in display panels. The company was represented by Elliott Reid and H. W. Rolinson.

Application of Anti-Friction Bearings

II

T. V. Buckwalter

THE first part of this article, which describes the application of anti-friction bearings on electric tractors and industrial trucks in the service of the Pennsylvania, appeared on page 377 of the June, 1916, issue.

About 25 steel hand baggage trucks of a light weight design have been constructed and placed in service within the past year. A general view of the truck is shown in the attached photograph and sectional view of the axle showing the bearing mounting is shown in photograph of drawing. These trucks are equipped with Timkin bearings on all four wheels, the bearings being mounted to take thrust in all directions, and to take the load equally. Two bearings are mounted in each wheel as shown in Fig. 13.

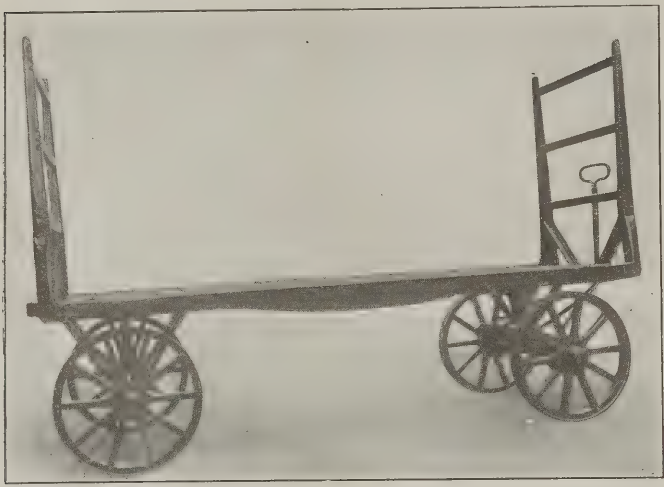


Fig. 12. Steel Hand Baggage Truck—Weight, 510 lbs.; Capacity, 4,000 lbs.; Length, 10 ft.; Height, 30 in. Timken Bearings.

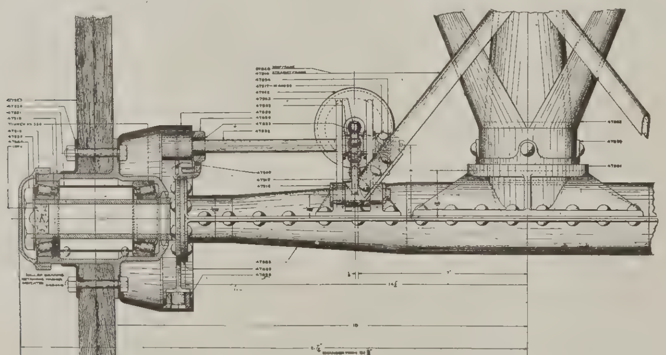


Fig. 13. Steel Hand Baggage Truck—Front Axle Section Showing Application of Timken Bearings.

The weight of this truck is 510 lb., of which the wheels represent 140 lb., leaving a net weight on the bearings of 370 lb. The capacity is 4,000 lb., making a total load on the bearings of 4,370 lb., or 1,090 lb. per wheel, or 545 lb. per bearing. The bearing used is the Timkin No. 336, having a rating at constant normal load of 625 lb. each. The weight on each bearing with normal load is therefore 87 per cent of the normal constant load of the bearing, and in addition to this load due to weight, there is some thrust load taken by these bearings due to road shocks and curving, but these thrust loads are considered to be negligible.

There are no records of failures of any of the bearings on steel hand baggage trucks, and the truck is considered to be the easiest running hand baggage truck that we have, which is due possibly to the light weight and roller bearing wheel mountings.

Trucks for Creosoting Plants

The trucks for creosoting plants were constructed to replace trucks furnished by outside manufacturers at creosoting and timber treating plants. Replacement was made on account of the failure of the former trucks to stand up in severe service, and also to the fact that the trucks must be moved by hand with a load approximating five tons for short distances, and this feature presented too many difficulties with the plain bearing trucks.

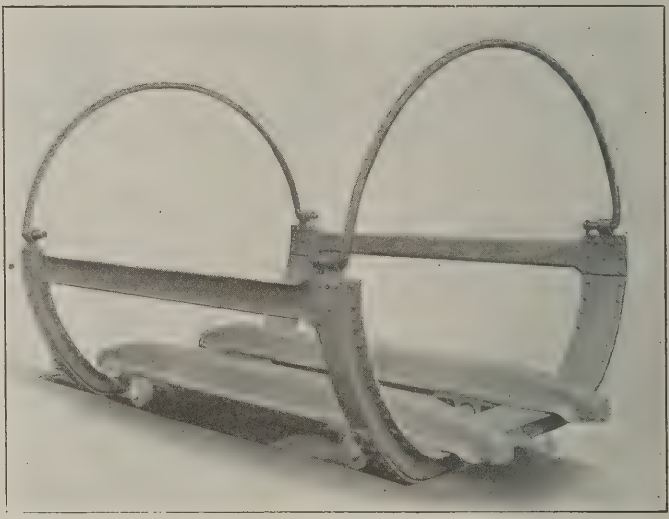


Fig. 14. Creosoting Plant Truck—Tie Truck.

The trucks are made in two general types, namely, tie trucks with four wheels and integral bolsters and timber trucks with four wheels and swinging bolsters, the object of the latter being to facilitate the loading of long timbers. The weight of the tie treating truck is 1,400 lb. and that of the timber truck 1,680 lb. The data regarding the timber trucks is as follows:

Weight of wheel and axles	450 lb.
Net weight on bearings	1,230 lb.
Capacity	10,000 lb.
Total weight on bearings	11,230 lb.
Load on each bearing when uniformly distributed	2,810 lb.
Normal capacity of bearing at 500 R.P.M.	1,920 lb.
Average speed of bearing at 10 miles per hour	280 R.P.M.

The bearings selected for this work are the Hyatt flexible roller type, all manufacturer's number 12,725.

A peculiarity of the Hyatt bearing is that it will not take thrust in any direction and is adapted to take radial load only. The thrust on the timber treating trucks, which is considerable, is taken directly on the hubs of the wheels on plain surfaces formed on the bearing housing.

Fig. 15. Creosoting Plant Truck—Train Tie Truck.

These bearings are loaded at times to 50 per cent. above their normal capacity, and in the five years they have been in service there are no recorded failures, although there are a total of 200 trucks in service.

It is interesting to note that no provision was made to lubricate the bearings on these trucks. The only lubricant they receive is the immersion in creosote at each treatment of their load of timber or ties.

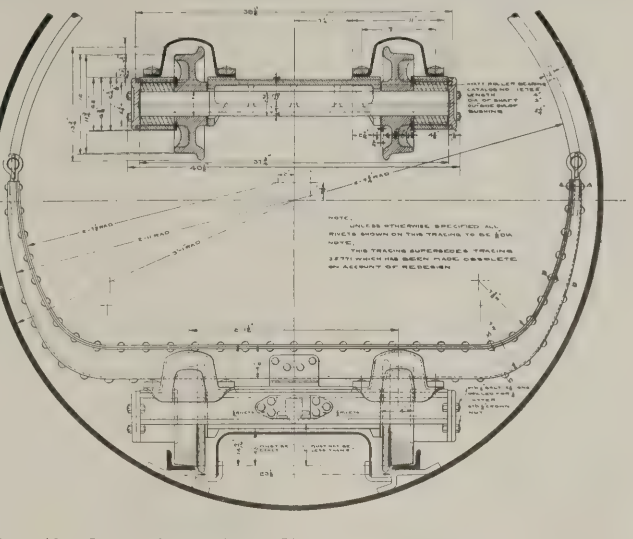

NOTE.
UNLESS OTHERWISE SPECIFIED ALL RIVETS SHOWN ON THIS TRACING TO BE ⅝ DIA
NOTE.
THIS TRACING SUPERSEDES TRACING 32771 WHICH HAS BEEN MADE OBSOLETE ON ACCOUNT OF REDESIGN

Fig. 16. Creosoting Plant Trucks—Sectional End Elevation Showing Mounting of Hyatt Bearing and Provision for Taking End Thrust.

M. C. B. Report on Car Lighting

THE rapid growth in recent years of axle-light devices for car lighting, the recent appearance of light-weight "body suspended" car-lighting generators differing radically from the earlier forms arranged for truck suspension, improvements in details of car-lighting accessories, rendering certain parts heretofore accepted as Aecommended Practice obsolete, and the improvement in the art of incandescent-lamp manufacture and reduction in lamp cost, make available an additional unit for car-lighting work, etc.; in consideration of these facts it appeared advisable to the committee to review the work of the Train Lighting and Equipment Committee since its inception, and as a result the committee suggests a revision of certain Recommended Practices, as follows:

Change the present paragraphs 23, 27 and 28 to the following:

3. *Clearances.*—(a) The axle-generator suspension shall be so designed that with car on level track the clearances shall be as great as possible but not less than those specified below:

(b) From any part of the generator or suspension to the rail ....6 in.

(c) On truck-suspended generators from any part of the generator or suspension to the car body or any part attached thereto.........................3½ in.

(d) With all parts of the car and axle generator affecting the clearances, in the same condition as when new, with the minimum belt tension to drive load and with the generator in any service position with respect to the suspension and with the truck in any service position with respect to the car body, the clearance from any part of the belt to the end sill, brake beam or to any other part of car body or truck shall be as follows:

	End Sill		Brake Beam		To any other part car body or truck
	Over	Under	Over	Under	
Truck supported......	1 in.	1½ in.	2½ in.	1 in.	½ in.
Body supported.......	1½ in.	1½ in.	3 in.	1 in.	1 in.

(e) With any or all parts of car and axle generator worn to the allowable limits and other conditions the same as in paragraph (d), from the belt to any part of the truck or car body.........................½ in.

Change paragraphs 25 and 26 to the following:

4. *Generator.—Suspensions.*—(a) In axle-generator suspensions, all supporting parts subject to wear shall have the wearing surfaces bushed.

(b) All axle generators shall be provided with safety chains or an equivalent construction which will safely support the generator in case of failure of the suspension.

(c) In truck-supported axle generator suspensions, if side arms be used, the end to be secured to the truck frame shall extend under the transom and be secured to the side frame near the transom and shall be securely attached to the end sill by a U bolt not less than ¾ in. in diameter, or a construction equivalent in strength.

Add: 7. *Generator.—Armature Pulley.*—(c) On all sleeve bearing axle generators having armature pulleys 8 in. in diameter or larger, the armature pulley shall be in accordance with the dimensions as shown in Fig. 1.

(d) On all axle generators having armature shafts less than 1½ in. in diameter at inner end of pulley seat, the armature pulley shall be in accordance with Fig. 2.

Add: 8. *Generator.—Armature Pulley Seat.*—(c) On all axle generators having armature shafts less than 1½ in. diameter at end of pulley seat, the pulley end of armature shaft, the nut, key and cotter pin shall be in exact accordance with the dimensions shown in Fig. 3.

Change paragraph 17 to 11 as follows:

11. *Batteries.—Boxes, Ventilation of.*—(a) Each battery box shall be provided with adequate ventilation as follows:

(b) Inlet openings located on the longitudinal center line of the floor of the battery box having a combined area of approximately six sq. in. for each 22⅝-in. compartment.

(c) Outlet openings located near the top of the battery box having a combined area of approximately six sq. in. for each 22⅝-in. compartment.

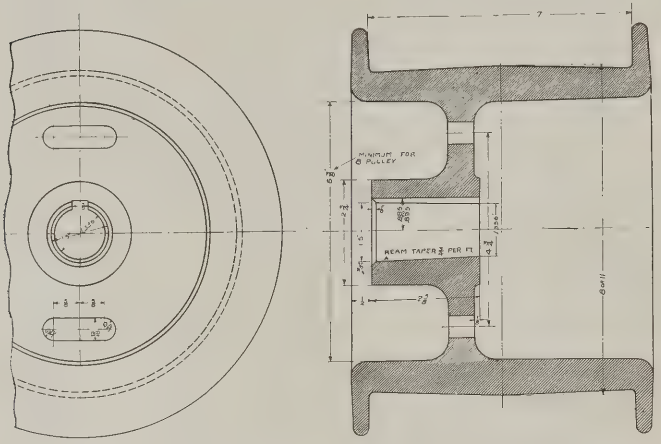


Fig. 1—Armature Pulley for 8 in. or Larger Pulleys for Sleeve Bearing Generator

Change paragraph 15 to 12 as follows:

12. *Batteries.—Trays, Dimensions of.*—Storage batteries for car lighting service shall be assembled in trays whose maximum dimensions shall not exceed those given in Fig. 4 when used in battery box having minimum dimensions given in paragraph 10 (a).

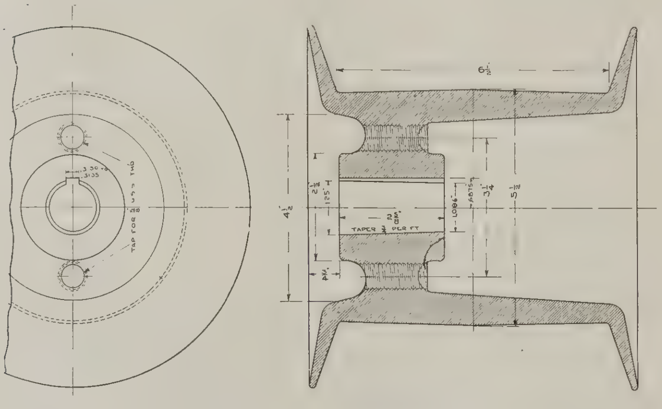


Fig. 2—Armature Pulley for Axle Generators Having Armature Shafts Less Than 1½ in. in Diameter.

Change paragraph 11 to 15 as follows:

15. *Batteries.—Fuses, for, Etc.*—(a) That each electrically lighted car equipped with battery box or boxes shall be provided with suitable metal fuse boxes, said boxes to be mounted close to the positive and negative terminals of each set of batteries, as shown in Fig. 5 and Fig. 6.

(b) These fuse boxes shall have mounted in them a block provided with fuse contacts having a capacity of 101 to 200 amperes. (The knife blade and screw contacts of the Standard N. E. Code were shown as being desirable for this purpose.)

Change paragraph 6 to 17 as follows:

17. *Wiring.—Train Lines and Connectors.*—(a) Cars operated in head-end system trains shall be equipped with three train line wires of No. 4/0 A. W. G.

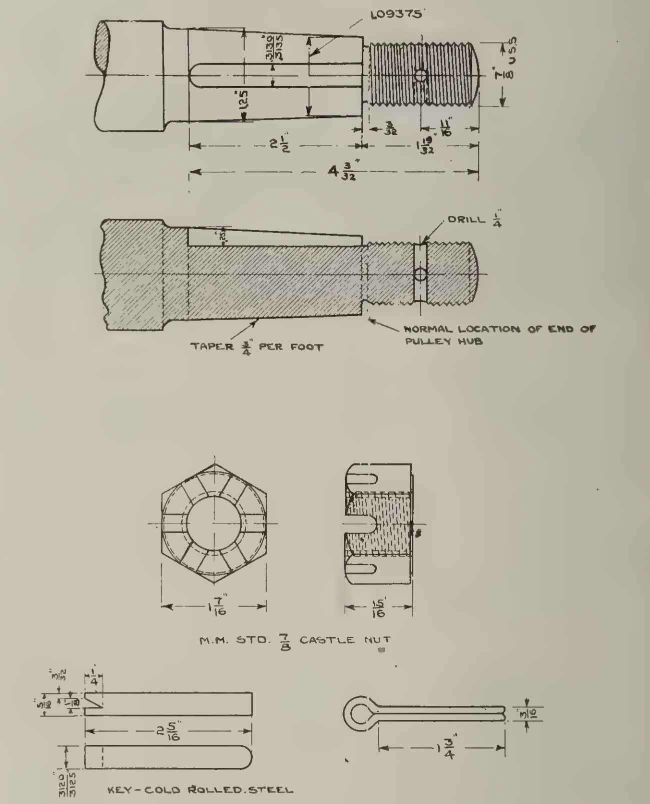


Fig. 3—Nut, Key and Cotter Pin for Pulley Shown in Fig. 2

(b) Cars not operated in head-end system trains may be equipped with two train line wires of No. 2 A. W. G.

(c) All cars equipped with train lines shall have the wires terminate in train line receptacles so designed that a standard train line connector such as shown in Fig. 7 and located as shown in Fig. 8 may be used.

(d) If only two wires are used they shall be connected to the outside terminals and the train line receptacle on each end of the car shall be stencilled: "NOT FOR USE ON HEAD-END SYSTEM."

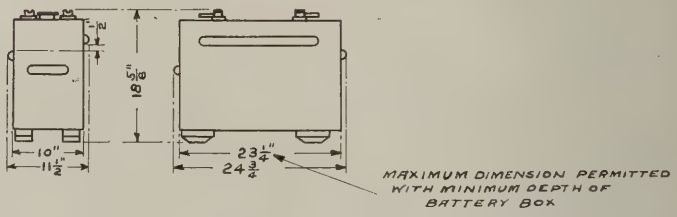

2
18⅝"
10"
11½"
23¼"
24¾"
MAXIMUM DIMENSION PERMITTED WITH MINIMUM DEPTH OF BATTERY BOX

Fig. 4—Maximum Dimensions of Batteries Assembled in Trays

(e) Where train line wires are used they shall be transposed as shown in Fig. 9.

Change paragraph 22 to 18 as follows:

18. *Wiring.—Generator Leads.*—The electrical connections between the axle generator and permanent wiring on the car shall be made in such a manner that the leads cannot be transposed.

Change paragraphs 3 and 4 to 21 as follows:

21. *Wiring.—Installation of Conduit and Wire.*—The following rules shall be used for car wiring:

(a) *Conduit.*—All conduit shall conform to the requirements of the National Electrical Code. It shall, wherever possible, be run on the interior of the car but not exposed to view. Ends of conduit shall be cut square and the interior reamed smooth, the contour of the material from the inner to the outer wall at the ends being approximately a quarter circle. Conduits shall not "butt" in couplings. Where threads on conduit are exposed they shall preferably be red or white leaded and painted. The conduit shall be of such a size and so arranged that the wires may be pulled in after the car is completed and pulled out for repairs without it being necessary to remove the interior finish of car. Conduit less than ⅜ in. shall not be used. Conduit and fittings shall be firmly and securely attached to the car body. The conduit system shall be so installed as to form a good, continuous electrical conductor and shall be grounded to the framework of the car. On steel or steel-underframe cars the supports of the conduit system will be considered as constituting an adequate ground. On wooden cars the conduit system shall be grounded by means of a copper wire of not less than No. 6 A. W. G. securely attached to the conduit and to some portion of the steel work of the car that has an electrical connection with the rail, so as to form a good electrical connection at the points of attachment. The connections of the ground wire shall be exposed to view and easily accessible.

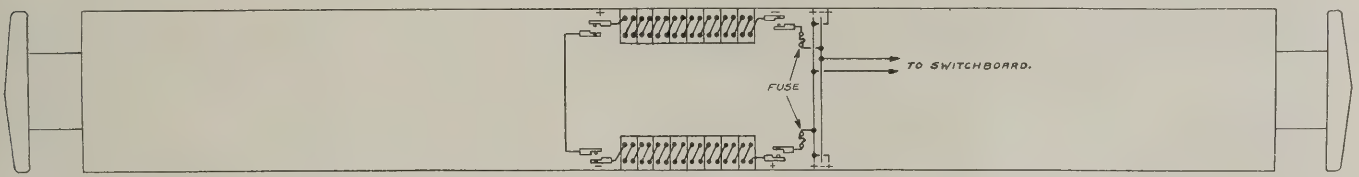


Fig. 5—Method of Connecting Set of Batteries to Car Wiring

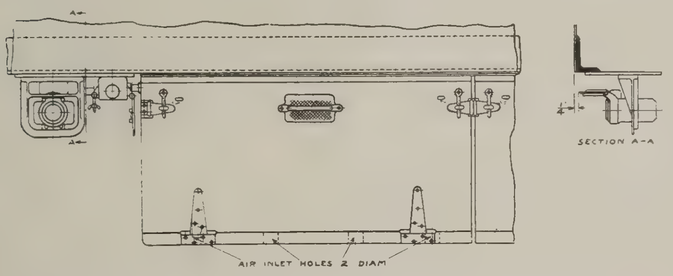


Fig. 6—Location of Charging Receptacle Fuse Block and Arrangement for Ventilation of Battery Box

(b) *Fuse, Junction Boxes, Etc.*—Fuse, Junction, outlet, connection and pull boxes exposed to the weather shall be of cast iron. The wall thickness at the bosses for the conduit shall be such as to ensure at least five threads of the conduit are engaged and that the interior of the boss be rounded off so as to provide the equivalent of an outlet bushing. "Knock-out" boxes or pressed or formed steel boxes may be used when not exposed to the weather, and, when used, locknuts shall be used on the conduit on both sides of the box wall and an outlet bushing on the end of the conduit. Pull boxes shall be installed where, on account of the length of run or number of bends, it would otherwise be difficult to pull in the wires. Fuse boxes for the main battery fuses shall be installed as close to the terminals of the battery, both positive and negative, as possible. All boxes shall be so installed as to render the covers of same readily accessible. The covers of boxes exposed to the weather shall be applied in such a manner as to render the box "weatherproof."

(c) *Wire.*—All wires shall be insulated with Grade "A" (30 per cent Para rubber) insulation if mineral base compound be used according to the specification of the Association of Railway Electrical Engineers, or equivalent, and shall be double braided, or if a wax base compound be used it shall be of a corresponding quality. No wire smaller than No. 14 A. W. G. shall be used, except for fixture work where No. 18 A. W. G. is permissible. All wires shall be run in metal conduit. No wire shall carry, under normal operating conditions, a current in excess of the values permitted by the National Electric Code for the size of wire in question. Train line wires on cars intended for service on head-end system shall be No. 4/0 A. W. G. Train line wires on cars not intended for service on head-end system shall be No. 2 A. W. G. All wires of No. 8 or larger shall be stranded. Train line connection between cars shall be as follows:

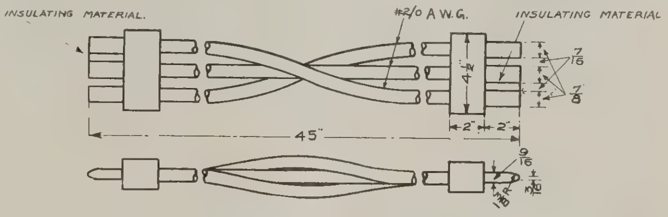


Fig. 7—3G Train Line Connector (3-Wire for Head End System)

Head-End System.—No. 2/0 A. W. G., 833 strands or more, 5-64 in. insulation and one braid.

Not for Head-End System.—No. 2 A. W. G., 133 strands or more, 4-64 in. insulation and one weatherproof braid. The leads from the generator to the terminal connector on the car body shall be as follows:

Armature Leads.—No. 4 A. W. G., 61 strands, 4-64 in. insulation, one weatherproof braid.

Field Leads.—No. 8 A. W. G., 19 strands, 3-64 in. insulation, two weatherproof braids.

Joints and Splices.—The insulation shall be removed from the wire in such a manner that the wire shall not be cut, scored or nicked. All joints and splices shall be so made as to be both mechanically and electrically secure without the use of solder. All joints and splices shall be soldered, the soldering flux shall be free from acid. All wires joined or spliced shall be installed in such a manner that the joint or splices come in a junction box or fitting. Slack shall be left in wires at junction boxes and other outlets. Care should be taken that no sharp end of wire or solder is left to pierce the insulation and cause a ground. The joint or splice shall be covered with a rubber tape to the thickness of the original insulation, and this covered with friction tape to the overall diameter of the complete insulated wire.

[Note.—The entire Recommended Practices under "Train Lighting" were revised and regrouped, but only the more important changes are considered here.—Editor.]

Rule 12-C of Code of Rules Governing the Condition of and Repairs to Passenger Cars in Interchange was drafted several years ago and it was then felt that electrically lighted cars were of superior class and therefore a charge of 75 cents per day was justifiable to cover the use of the electrical equipment. The committee has given a thorough study to this matter, as a result of which it is recommended that this rule be eliminated and that Rule 12-E be changed to read as follows:

"On electric head-end lighting system of passenger-equipment trains the expense of an attendant, if furnished, shall be prorated among the roads in interest on a mileage basis."

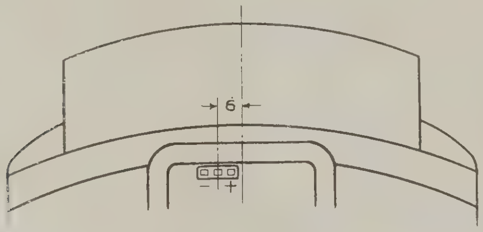


Fig. 8—Location of Receptacle for Train Line Connector

It is further recommended that Rule 12-D be changed to read as follows:

"For repairs to electric-lighting equipment on cars in interchange, or leased cars, the instructions issued by the manufacturers of the apparatus should be strictly followed. In the absence of any agreement the material furnished and applied must be of the same manufacturer's make and quality as that which it replaces."

This change is suggested to make clear the intent of the rule.

The committee has given careful consideration to the matter of standardizing lugs on axle generators whereby standard makes and types would become interchangeable for standard forms of suspension. This question involves not only the location of lugs on the axle-generator frame, but also the question of truck, car and suspension design, and the number of variables in these items is so great that the committee believes a satisfactory solution of the problem is impossible.

On page 41, paragraph 21, Volume 49, Part 1, 1915 Proceedings of the M. C. B. Association, reads as follows: "A member suggests that the matter of electric train line jumper connections be considered as standard for passenger cars." This was referred to this committee by the Committee on Revision of Standards and Recommended Practice. The committee feels, on account of the proposed changes in "Recommended Practices" as embodied in this report, that it is not advisable at this time to make any recommendations concerning advancement to "Standards."

Discussion

Mr. Davis (chairman): I would like to say a word about the elimination of rule 12-C. The report shows very clearly why the committee feels that a charge of 75 cents a day should be eliminated, but since sending the report to the secretary it has come to our attention that there is a feeling existing that the present rental charge for cars as determined by the American Railway Association, which is determined on the seating capacity and class of car, is not sufficient, and until these charges prescribed by the association are adjusted somewhat upward, that this charge of 75 cents a day for use of electrical equipment on cars should be retained.

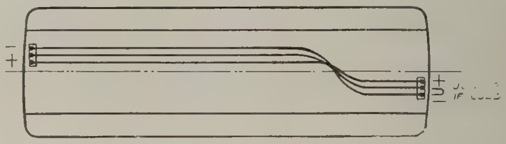


Fig. 9—Method of Transposing Train Line Wires (3 Wires)

Of course, your committee on this subject would have no suggestions to offer the American Railway Association as to what the equipment of cars should be, whether electric lights or gas lights, and it occurred to us that if it is desirable to make any charge for the use of electrical equipment, it might be as well to use the charge prescribed by the American Railway Association. But since electric lighting has now come into general use, and since we can now equip a car with the necessary devices and batteries with the standard thirty-volt system at practically one-half the cost we could five or six years ago when the committee first recommended this charge of 75 cents per day, and as the equipment is much more reliable in its performance, the chairman of the committee does not feel that any charge should be specifically made for the use of the electric lighting equipment on the car. It ought to be considered a car, and the rental value determined on the basis of seating capacity and class of car.

G. W. Rink (C. of N. J.): I see there are two styles of axles shown, it not being mentioned in regard to the finishing of that part of the axle between the wheel pits; our experience with an axle of that type, drop forged, has been very disastrous, due to the fact that we lost considerable pull through vibration, the center portion of the axle being slightly concentric. We have now gone to the straight axle fit, and that permits us to use one size pulley sleeved. This comes in very handy, when you consider that you have to change the position. In the case of the four-wheel truck, we have the pulleys about 4 in. off center. I think, in view of standardization, we ought to try, if possible, to eliminate the M. C. B. axle and stick to the one-sized axle, with a straight fit.

Mr. Davis: It occurs to me that the suggestion is a very good one, and I do not know at this moment why the committee did not specify that the straight axle should be rough turned.

E. W. Jansen (I. C.): The tapered axle shows a straight taper. That naturally means rough turned. On the straight axle the exact diameter is given, and it was intended that it be rough turned.

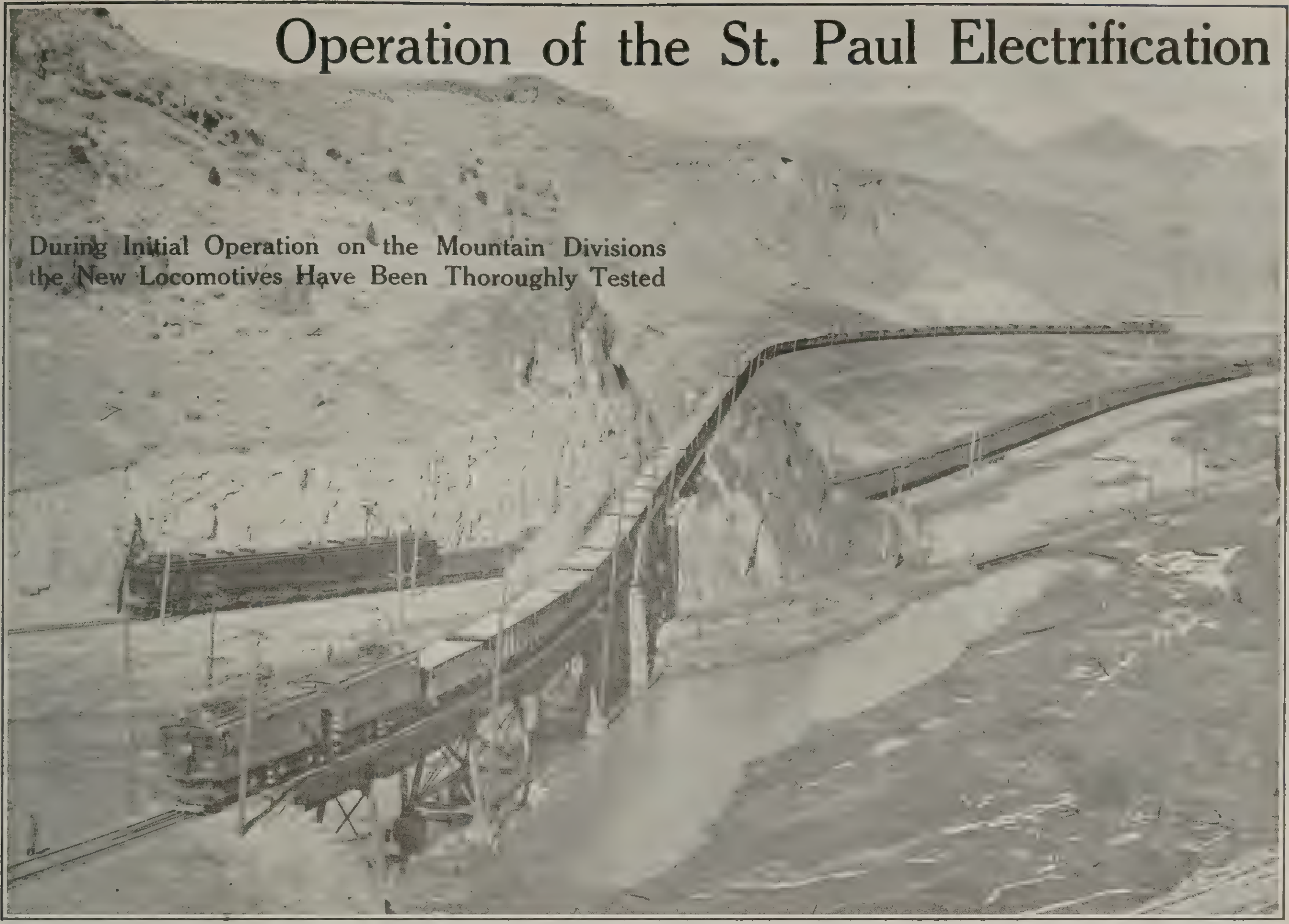
J. R. Sloan (Penna.): It is simply a matter that the committee overlooked. We all mean to have it rough turned. Mr. Cartwright, will you please restate your motion?

Mr. Cartwright: I move that the report of the Committee on Train Lighting and Equipment be received, in accordance with the recommendation of the committee, that the committee be continued.

See 344

Operation of the St. Paul Electrification

During Initial Operation on the Mountain Divisions the New Locomotives Have Been Thoroughly Tested



Ore Train on the Butte, Anaconda & Pacific and Freight Train on the Chicago, Milwaukee & St. Paul

WHILE many terminal and tunnel installations have been made in the past for the purpose of eliminating smoke, taking care of suburban traffic or other local conditions, the Chicago, Milwaukee & St. Paul electrification is the first project of the kind where electric locomotives were installed to operate over several engine divisions.*

The Electrified Divisions

The four steam engine divisions which were selected for electrification aggregate 440 miles in length. Steam engines were first abandoned on the Three Forks-Deer Lodge Division, 115 miles long, and crossing the main Continental Divide, thus giving the electrical equipment its initial tryout under the severest service conditions of the entire system. The first electric locomotives were placed in regular service on December 9, 1915, and during the month of April, 1916, service was extended to Harlowton, making a total of 220 miles of electrically operated road. By the first of November, 1916, it is expected that steam engines will be superseded over the entire distance of 440 miles from Harlowton, Montana, to Avery, Idaho. The length of track between Harlowton, Montana, and Avery, Idaho, is approximately equal to that from New York to Buffalo or from Boston to Washington.

In crossing the three mountain ranges included in the electric zone, there are several grades of one per cent or more, the most difficult of which is the 21 mile two per cent grade between Piedmont and Donald, and the longest the 49 mile one per cent grade on the west slope of the Belt Mountains.

The curvature is necessarily heavy, the maximum being 10 degrees. There are also numerous tunnels in the electric zone, 36 in all, of which the longest is the St. Paul Pass tunnel, over a mile and a half in length, through the ridge of the Bitter Root Mountains.

The passenger service consists of two all-steel finely equipped transcontinental trains in each direction, the "Olympian" and the "Columbian," and a local passenger train in each direction daily between Deer Lodge and Harlowton.

Freight traffic through the electric zone comprises from four to six trains daily in each direction. Westbound, the tonnage is made up of manufactured products and merchandise for Pacific Coast points and foreign shipment. Eastbound tonnage includes grain, lumber, products of the mines and some live stock.

As a larger part of the traffic is *through* freight, trains are made up of an assortment of foreign cars, including box and flat cars, coal and ore hoppers, stock cars, refrigerators, etc., varying in weight from 11 to 25 tons empty and as high as 70 tons loaded. These cars being owned by many different railway systems are equipped with air brakes adjusted for different conditions of operation, and in accordance with different standards as to braking power and type of equip-

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*Previously described in the December 1914, January 1915 and November 1915 issues of the *Railway Electrical Engineer.*

ment, thus making the problem of holding the long trains on the heavy down grades by air brakes a most difficult one.

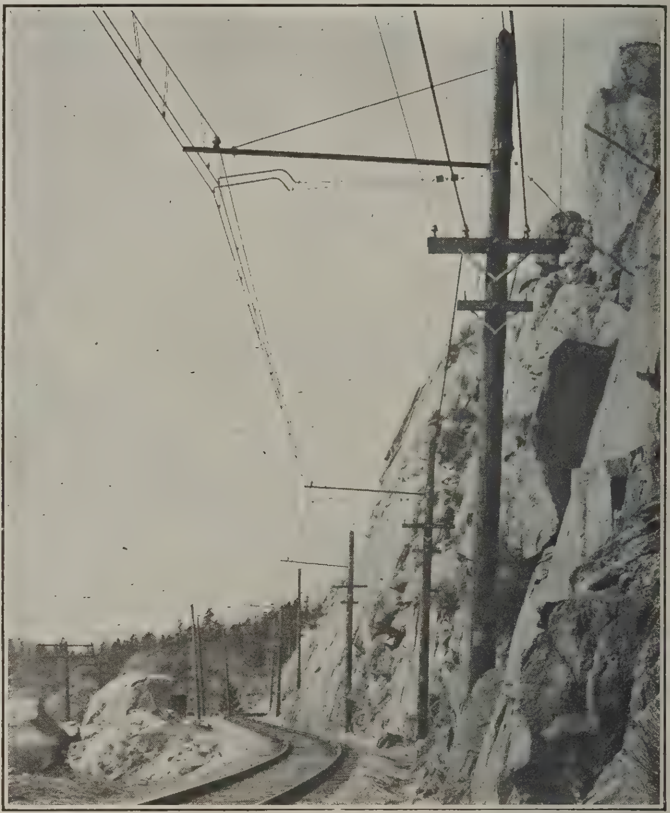
Electrical Operation

Electrification promises a material reduction in running time. It has been found, for example, that on the 21 mile two per cent grade from Piedmont to Donald, the electric locomotive can reduce the running time of passenger trains from an hour and five minutes to approximately 40 minutes. On the run from Deer Lodge to Butte which, under the steam locomotive schedule, required an hour and 20 minutes, a saving of approximately 30 minutes can be made.

In the freight service, it has been found that on the first division where the steam locomotives have required 10 to 12 hours to make 115 miles, electric locomotives can meet a schedule of from seven to eight hours for the same distance. The heavy grades and frequent curves at certain points offer serious obstacles to steam locomotive operation even in the summer time, but with winter temperatures as low as 40° F. and heavy snowfalls in the Bitter Root Mountains, serious delays have occurred, owing to engine failures or to inability to make steam. The capabilities of the electric locomotives are in no way impaired by cold weather or by inability to obtain fuel or water in case of snow blockades. During a series of record-breaking temperatures in December, 1915, Mallet engines were frozen up at different points on the system and the new electric equipment was rapidly pressed into service to replace them. On several occasions electric locomotives hauled in disabled steam engines and trains which would otherwise have tied up the line.

Ten Degree Curve at the Western Entrance of Silver Bow Canyon Showing Feeder Taps

During initial operation on the Rocky Mountain Division, the capacity of the new locomotives has been thoroughly tested. Trains of 3,000 tons trailing have been hauled east and 2,800 tons west, using a helper on the heavy grades. From the operating data obtained on the first division, it is evident that much heavier trains can be hauled with the electric locomotives than with steam engines, and all passing tracks are being lengthened to take advantage of longer trains. On some of the runs where the grades are less than one per cent trains of as many as 130 cars and as heavy as 4,000 tons have been hauled with a single locomotive.



Curve Construction on 2 Per Cent Grade. The Double Feeders Used on This Grade Are Also Shown

The four through passenger trains, "Olympian" and "Columbian," are taken across the two mountain ranges by a single passenger locomotive. These trains at present consist of eight full vestibuled steel coaches, weighing approximately 650 tons. Instead of changing locomotives at Three Forks, as has been the practice under steam operation, the same locomotive is run through the 220 miles from Deer Lodge to Harlowton, changing crews midway. Passenger trains will travel over the entire electrified division in approximately 15 hours, including all stops, and the tourist thus will have an opportunity of traversing by daylight some of the most beautiful scenic regions in the United States and without suffering the annoyance of cinders and smoke incident to the use of steam locomotives. The local passenger train operating in the electric zone between Deer Lodge and Harlowton is handled by a half unit weighing about 150 tons with equipment similar to the main line locomotives.

Locomotives

The development of the electric locomotive is primarily the achievement which has made electrification of trunk lines feasible. The main line Chicago, Milwaukee & St. Paul electric locomotives are constructed in two units permanently coupled together, the halves being duplicates and each capable of independent operation. The enormous tractive effort of these electrical giants will be appreciated when it is stated that the wood burning locomotive of 50 years ago weighed 20 tons and had a tractive effort of only 5,000 pounds. The modern Mallet steam locomotive weighing 278 tons with tender, which has been released, has a tractive force of 76,200 pounds, while the electric locomotive, weighing 282 tons, has a running tractive force of 85,000 pounds and a starting tractive force of 136,000 pounds.

Train No. 16 Descending 2 Per Cent Grade on Eastern Slope of the Rockies

There are 42 of these main line locomotives (30 freight and 12 passenger) and two switching locomotives. The locomotives are the first to be used for railroad service with direct current motors operating at a potential as high as 3,000 volts and the first to use direct current regeneration. The passenger locomotives are equipped with a gear ratio permitting the operation of 800 ton trailing trains at speeds of approximately 60 miles per hour on tangent level track. The average passenger train weighs from 650 to 700 tons and is hauled over the two per cent grade without a helper. The freight locomotives are designed to haul a 2,500 ton trailing train at approximately 16 miles per hour on all grades up to and including one per cent. On two per cent grades the trailing load was limited to 1,250 tons, although this figure has been exceeded in actual operation.

A motor-generator set in each half of the locomotive furnishes low-voltage current for the control circuits, headlights, cab lighting and for charging the storage batteries on the passenger coaches. Under steam operation, the charging current for these batteries is furnished by a steam turbo-generator set located on the locomotive. The blower for ventilating the traction motors is also direct connected to one end of this set.

The pantograph collectors, one of which is mounted on each half of the locomotive, are of the double pan type with a working range of from 17 ft. to 25 ft. above the rail. The contact elements are of the same metal as the trolley wire, so that current passes from copper to copper.

The switching locomotives are of the swivel truck type, weighing 70 tons each, and equipped with four geared motors. A single pantograph of construction similar to that used on the main line locomotives is mounted on the cab and in other ways the locomotives represent the standard construction commonly used with the steeple cab type of switcher. The motors (known as Type GE-255) are of box frame, commutating-pole, single-geared type designed for 1,500 volts with an insulation of 3,000 volts to the ground. Many of the switching locomotive parts are interchangeable with those used on the main line locomotives; for example, the air compressors, small switches, headlights and cab heaters.

Power Supply

Utmost precautions were taken by the railway company in making plans for this electrification to insure a reliable source of power. The Montana Power Company, with whom the contract was closed for electric power, operates a network of transmission lines covering a large part of Montana, which are fed from a main plant at Great Falls, and a number of other widely separated water power plants of adequate capacity at all seasons of the year. A notable feature of this pioneer electrification is, therefore, the conservation of fuel consequent upon the utilization of water powers. The Montana Power Company's transmission lines, which are carried in some cases on steel towers and in others on wooden poles, tap into the railway system at seven different points where the power is most needed. The railway company's transmission line extends the entire length of the system on wood poles. In most cases this line is built on the company's right-of-way, although at several points there are cutoffs which make a considerable saving in the length of line. With this completely inter-connected transmission system, each substation may be fed from either direction and also at the tie-in points from a third source of power.

Two 2,500 KV-A 3-Phase 100,000/2300 V. Transformers and Oil Switches in Morel Sub-Station

Overhead Construction

The overhead construction is of the modified flexible catenary type designed by the General Electric Company and installed under the direction of the railway company's engineers. With this quite novel but remarkably successful construction, the current is collected in both high speed passenger service and heavy freight service without sparking. As may be seen from the illustrations, the construction comprises two 4/o copper wires flexibly suspended side by side from the same steel messenger by independent hangers alternately connected to each wire. Bracket construction is used wherever the track alignment will permit, and cross span construction on passing tracks and in the switching yards. All of this work is supported on 40-ft. wooden poles suitably guyed and spaced.

The standard transmission pole consists of 45- and 50-ft. wood poles with two cross arms carrying 100,000-volt lines on suspension type insulators and also an uninsulated ground wire. There are a number of modifications of this construction on curves, at corner points, substation entrances, etc.

A 500,000 c.m. feeder is installed the entire length of the electrification and a supplementary feeder on heavy grades. The feeder is tapped to the trolley wire at every seventh pole, or approximately every 1,000 ft. On top of the poles is carried a supplementary 4/o negative feeder which is tapped to the middle point of every second reactance bond. These bonds are used for insulating the 60-cycle signal circuits and are installed at points overaging from 5,000 to 6,000 ft. apart.

General View Great Falls Dam and Power House at Volta, Mont. Four 10,000 KW Vertical Generators Feed, Chicago, Milwaukee & St. Paul Railway Electrification.

Each track is bonded with a 250,000 c.m. bond on each joint and double bonded on the heavier grades.

Electric locomotion has been adopted by the Chicago, Milwaukee & St. Paul with the expectation of effecting a sufficient reduction in the cost of operation to return an attractive percentage on the investment required, as well as to benefit by all the operating advantages of electric locomotives. According to statements made by the railroad officers, about $12,000,000.00 will be expended, and with the work more than half completed there is every reason to believe that the cost of construction will come inside the estimates.

Summary

The advantages expected to result from the electrification are:

Marked reduction in cost of electricity as compared with cost of coal.

Reduction in maintenance cost of locomotives.

Elimination of delays due to coaling, taking water, oil, etc.

Elimination of delays due to natural causes, such as freezing of locomotives, loss of steam in cold weather, bucking snow drifts.

Elimination of non-revenue trains hauling coal and water for steam locomotives.

Increased tonnage per train.

Increased train speed on grades.

Greater reliability and certainty of maintaining schedules.

Reduction in train crew hours per ton mile.

Reduction in damage to rolling stock due to rough handling by steam engines.

Greatly increased safety of operation on grades due to regenerative braking.

Saving in power and reduction in wheel and track wear by use of regenerative braking.

Improvement of tunnel conditions due to smoke and gas, absence of smoke and cinders which obscure scenic attractions, uniform speed and absence of grinding brake shoes on grades, all of which accrue to the benefit of the traveler on the transcontinental passenger trains.

View in Tunnel No. 13, Showing Collapsible Hanger Used for Tunnel Work

Condensed Technical Data

Location and Equipment of the Fourteen Substations

Station	Miles from Harlowton	No. and size of units in kilowatts	Substation capacity in kilowatts
Two Dot	12.	2–2,000	4,000
Summit	45.6	2–2,000	4,000
Josephine	75.8	2–2,000	4,000
Eustis	105.8	2–2,000	4,000
Piedmont	148.5	3–1,500	4,500
Janney	175.9	3–1,500	4,500
Morel	209.3	2–2,000	4,000
Gold Creek	244.9	2–2,000	4,000
Ravenna	277.6	2–2,000	4,000
Primrose	315.4	2–2,000	4,000
Tarkio	352.	2–2,000	4,000
Drexel	390.1	2–2,000	4,000
East Portal	413.9	3–2,000	6,000
Avery	437.6	3–1,500	4,500
		32	59,500

Main Line Freight Locomotives

Type of locomotive	3,000 volts d-c.
Length overall	112 ft.
Total wheel base	102 ft. 8 in.
Rigid wheel base	10 ft. 6 in.
Total weight	564,000 lb.
Weight on drivers	448,000 lb.
Weight per driving axle	56,000 lb.
Weight per guiding axle	29,000 lb.
Diameter of driving wheel	52 in.
Diameter of guiding wheel	36 in.
Number of driving motors	8
Total output (continuous rating)	3,000 hp.
Total output (1 hour rating)	3,440 hp.
Tractive effort (continuous rating)	71,000 lb.
Per cent of weight on drivers (trac. coef.)	15.83
Speed at this tractive effort at 3,000 volts	15.75 m.p.h.
Tractive effort (1 hour rating)	85,000 lb.
Per cent of weight upon drivers (trac. coef.)	19
Speed at this tractive effort at 3,000 volts	15.25 m.p.h.
Tractice effort available for starting 30 per cent coef	136,000 lb.

The passenger and freight locomotives are identical with the exception of gear ratio and the addition of an oil-fired steam boiler in each half of the passenger locomotives for heating the trailing coaches. The two poilers are capable of evaporating 4,000 pounds of water per hour and this equipment with tanks for oil and water bring the weight of the locomotive up to approximately 300 tons. The interchangeability of all electrical and mechanical parts of the locomotives is considered of great importance from the standpoint of operation and maintenance.

Switching Locomotives

Length inside knuckles	40 ft.
Height over cab	13 ft. 10 in.
Height—trolley down	16 ft. 8 in.
Width overall	10 ft.
Total wheel base	29 ft. 4 in.
Rigid wheel base	8 ft.
Diameter of wheels	40 in.
Weight—locomotive complete	140,000 lb.
Weight per driving axle	35,000 lb.
One hour rating of locomotive	542 hp.
Tractive effort at one hour rating	18,400 lb.
Speed at this rating	12 m.p.h.
Continuous tractive effort	13,480 lb.
Speed at continuous rating	13.2 m.p.h.
Tractive effort 30 per cent	42,000 lb.

Completed Hydro-Electric Plants

	Installed capacity, kw.
Great Falls, on Missouri River	60,000
Rainbow Falls, on Missouri River near Great Falls, completed in 1910	27,000
Black Eagle Falls, on Missouri River near Great Falls, reconstructed in 1913	3,000
Black Eagle Falls, hydraulic power, 8,000 hp.	
Hauser Lake, on Missouri River, northeast of Helena, completed in 1911	18,000
Canyon Ferry, on Missouri River, northeast of Helena, completed in 1898 and enlarged in 1901	7,500
Madison No. 1, on Madison River, 60 miles southeast of Butte, completed in 1901 and remodeled in 1907	2,000
Madison No. 2, on Madison River, 60 miles southeast of Butte, completed in 1906	10,000
Big Hole, on Big Hole River, 22 miles southwest of Butte, completed in 1898	3,000
Livingston, on Yellowstone River, completed in 1906 and enlarged in 1908	1,500
Billings No. 1, on Yellowstone River, completed in 1907	1,080
Lewistown, on Spring Creek, completed in 1906 and remodeled in 1913	450
Thompson Falls, on Clark's Fork of Columbia River	20,000
	153,530

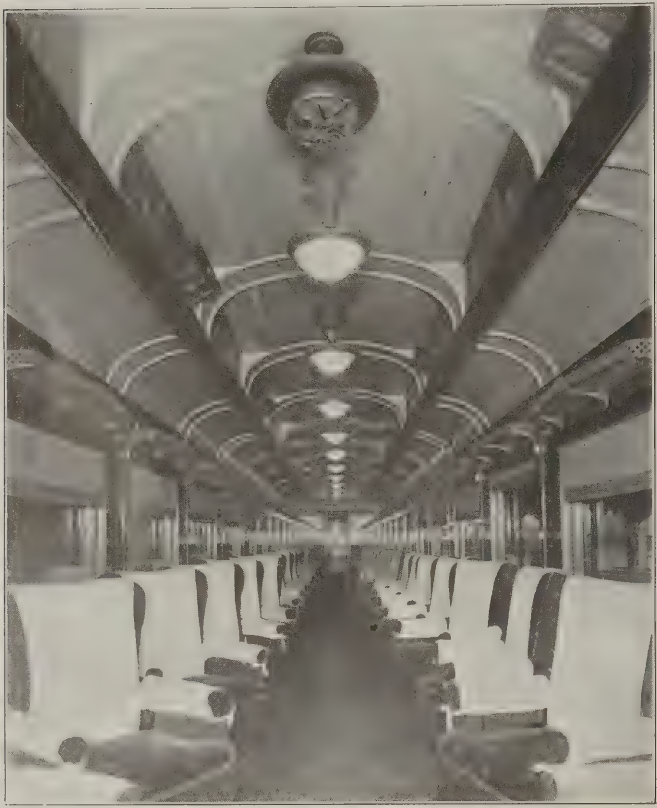
Pacific Coast Electric Railway

This company operates an electric road between Guadaloupe on the Southern Pacific Company's main line between San Francisco and Los Angeles and Santa Maria, Santa Maria being on the Pacific Coast Railway. (The Pacific Coast Railway is a steam railway operating between Port San Luis and Los Olivos.) The distance between Guadaloupe and Santa Maria is nine miles, as nearly level as possible and a straight track. The substation is at the Santa Maria end of the line. The principal use to which this road is put is meeting the main line trains of the Southern Pacific Company, with a single steel passenger coach equipped with Westinghouse narrow-gage commutating-pole motors and HL control. These passengers are carried to and from Santa Maria. During a ninety-day period in the fall of the year the road handles sugar beets for the Union Sugar Company. Other than this short interval of time no heavy traffic is handled.

Guadaloupe is a town of 500; Santa Maria is a town of 2,500. There are no towns between them, and except for the passenger business and the sugar campaign (the harvest season of the sugar beets is known as the sugar campaign), there is no source of revenue for this road. This road has a number of feeders running into the beet field, but the trains are gathered by means of steam locomotives on to the main line of the Pacific Coast Electric Railways.

A New Car Fan

As indirect lighting introduced an entirely new principle in the art of illumination, so it would seem the new type of fan illustrated herewith, developed by W. C. Hood and placed on the market by the Central Electric Co., Chicago, brings into use an entirely new principle in electric fan construction. The new fan employs the principle of the indirect lighting fixture in that instead of allowing the draft to come direct from the fan to the passengers, the fan blades are reversed, causing the current of air to be directed upwards against the curved surface of a large disk which serves as a deflector, redirecting the air downward again on all sides of the fan; this air movement, however, is so gentle as not to cause any direct draft on the heads of the passengers.

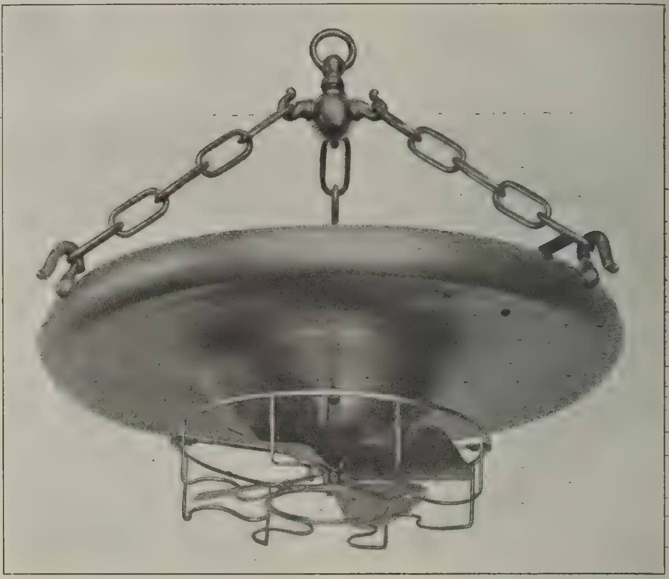


Application of the New Car Fan in a Parlor Car. The Fans Are Placed Two Fixtures Apart Down the Entire Length of the Car.

By testing the operation of the fan by watching the movement of smoke, it is observed that there is a constant movement of air upward immediately below the fan and for an angle of about 45 degrees to each side. Upon leaving the deflecting surface of the curved disk above the fan blades, the motion of the air is almost horizontal but in all directions. This latter movement striking the quarter deck of the cars or the sides of a room, is again deflected downward. The result of this is that there is a gentle air motion which gives a decided effect of coolness in the car or room without a draft.

The fan construction is very simple, the blades of the fan being simply reversed from the ordinary practice in fan construction so as to draw the air toward the motor instead of away from it, the motor, however, is concealed behind the curved portion of the deflecting disk as shown in the photograph accompanying the illustration. The curve of this large disk is so designed as to deflect the air at the proper angle and at the same time provide for handling this air with a minimum of resistance, insuring maximum operating efficiency.

The car interior in Fig 1 shows how nicely this new type of fan adapts itself in the car construction. This makes it possible to install fans throughout the entire length of the car without any appearance of congestion in ceiling features, which is a very important item and which has been the main objection to mounting other types of fans down the center of the car.



A Closer View of the Fan Showing the Deflecting Plate and the Mounting Details. It Will Be Noted That the Fan Blades Are Pitched to Throw the Air Up Instead of Down.

E.S.B. Body-Hung Generator

The Electric Storage Battery Company, Philadelphia, Pa., in connection with its constant voltage axle lighting system, exhibited at Atlantic City a new body-hung generator and suspension. The machine is hung from a cast steel frame or carriage, adjustable longitudinally on a pair of parallel rails, the belt tension spring being attached at one end to the generator frame and at the other end to a fixed point in the steel carriage. The carriage may be locked in any desired position on the rails by means of two cams. The belt tension is adjusted by sliding the carriage towards or away from the truck, the amount of tension being indicated by the angular position of the generator. Any stretch of belt may be quickly taken up without cutting, by sliding the carriage away from the truck until the generator assumes its normal angular position. Similarly, if it becomes necessary to cut out a defective portion of the belt, the belt may be shortened while still permitting adjustment for normal tension, thus avoiding an extra joint.

The same company is also exhibiting a new design of car-lighting battery. The elements are assembled in two-cell units of the slatted crate type, the lead-linings being separated from the wood work by sheets of specially treated tar-felt. The covers are of lead-alloy, sealed either by lead-burning or sealing compound as preferred. A large vent-opening is provided, covered with a lead vent cap held in place by its own weight and so designed as to provide a spray trap to prevent the escape of acid spray.

Shop Motor Section

XX—Special Transformers

J. H. Wickman*

IN the last article (XIX), both the potential and the current transformer were described so that, of the four special types of transformers mentioned, we still have the constant current and the subway transformers to study.

Constant Current Transformer

Alternating current is generally supplied at constant potential, consequently, when lamps or other apparatus requiring constant current are used it is necessary to equip the circuit with some means of transforming from constant voltage supply to constant current. A constant series reactance will maintain approximately constant current if the circuit is highly inductive, but the power-factor will be sacrificed. In order then to maintain constant current and at the same time a high value of power-factor it is necessary to insert in the circuit a series reactance, which changes with the load in such a manner as to keep the total impedance, and consequently, the current, constant. This variable reactance is obtained in the constant current transformer by means of two coils, movable with respect to each other.

Operation

In the constant current transformers made by the General Electric Company, shown in Fig. 70 for series incandescent or series arc lamps street lighting, one coil is stationary, while the other is suspended from a rocker arm to the other end of which weights are attached. These weights, together with the magnetic repulsion between the coils, counterbalance the weight of the secondary coil. At full load the coils should be about 2 in. apart, and as the load falls off the tendency for the current to rise, due to the decreased resistance of the secondary circuit, is offset by the separation of the coils. The separation is caused by the greater repulsion of the increased magnetic flux, due to the momentarily increased current in the secondary coil. With the coils farther apart more of the magnetic lines of force from the primary coil go out between the coils as leakage flux and the e.m.f. induced in the secondary is decreased in proportion to the fall in the secondary load, thus maintaining the current at a constant value.

Regulation and Efficiency

The General Electric transformers are designed so that the coil will separate sufficiently to maintain constant current, when all of the lamps are cut out of the circuit; in other words, they regulate from full load to no load maintaining constant current on the secondary within 1 per cent on either side of normal. The center of curvature of the weight sector arm is adjustable, as is also the amount of balancing weight. The efficiency is about 95 to 96 per cent at a power factor of 86 to 89 per cent.

Construction

All modern constant current transformers are air cooled. All parts are visible, open to free ventilation and easy to keep clean.

The 3 and 5 kw. sizes consist of one coil for primary and one for secondary. The 10 to 25 kw., inclusive, consists of two coils for primary and two for secondary with a 1 in. vertical duct between coils for ventilating purposes. Transformers of larger capacities, each consist of four coils for primary and four for secondary with a 1 in. vertical duct and ½ in. horizontal duct between coils to give a maximum radiating surface. All of these windings are made up of pre-treated double cotton covered wire, with a double thickness of varnish-treated muslin between layers. The coils are insulated with a high quality of varnish-treated cotton tape and are subjected to varnish and baking treatment before completion.

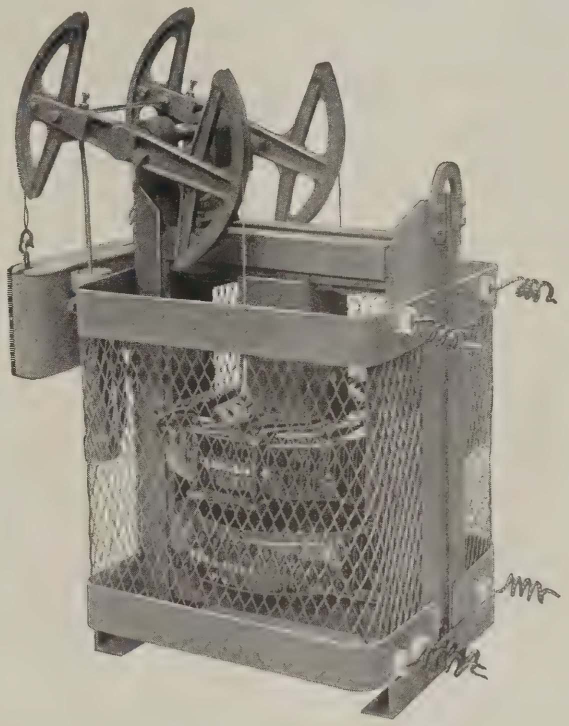


Fig. 70—General Appearance of a Constant Current Transformer

The core is built up of steel laminations rigidly held together by tubular brass rivets, insulated from the core by sleeves of cambric.

The frame is made up of structural steel, riveted to the three legs of the core. This allows of a very substantial construction and gives a compact and neat appearance to the outfit. All transformers are equipped with a protective screening of expanded metal, which can be easily removed for cleaning purposes if desired.

The balancing mechanism is supported on ball bearing and is mounted on top of the transformer to prevent the moving coil coming in contact with the end of the rocker arm. This construction, together with the high repulsion between coils insures instantaneous and sensitive regulation.

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The standard constant current transformers are designed for operation from an a.c. single phase 2,300 volt, 60 cycle constant potential source of supply. They can be built for any voltage up to 13,200 volts and for any frequency. The secondaries can be built for any current but the most popular ratings are 6.6 or 7.5 amperes.

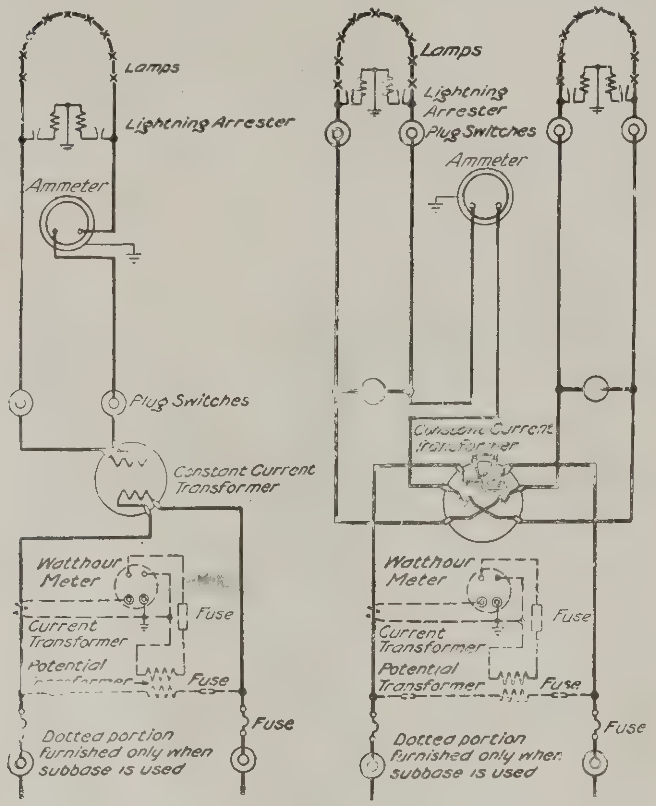


Fig. 71—Connection Diagram for Single and Double Circuit Secondary Systems Controlled by Constant Current Transformers.

Transformers of 10 to 25 kw. inclusive are provided with a partial load tap for 80 per cent of full rated load. Larger capacities have taps for 70, 80, and 90 per cent of full rated load. These taps are for the purpose of operating the outfit at partial load and still maintaining full load operation characteristics.

The voltage on the secondary of these transformers varies according to the number of lamps in the circuit; thus if each lamp takes 77 volts and there are 50 lamps in series the voltage across the secondary terminals would be 77 × 50 or 3,850 volts.

These transformers are usually designed for a single secondary circuit but by using a double circuit secondary control panel two secondary circuits can be obtained. The connection diagrams for both single and double circuit secondary systems are shown in Fig. 71.

Control Panels

Constant current transformers are usually controlled by individual panels either mounted separately near each transformer or combined as a switch board.

The ammeters are connected directly in series with the secondary circuits, and on all panels on which the secondary voltage exceeds 2,300 volts, the ammeter is provided with an insulating cover and with bushings for the studs where they extend through the panel.

The ammeters have movable markers which may be set at the requisite current value so that any deviation of the current may be readily detected.

The primary switches consist of standard plug switch and tubular expulsion fuse combined in a single unit, the fuses being of such capacity as to rupture the circuit only under emergency conditions equivalent to a short circuit on the transformer.

Open circuiting secondary plug switches are provided on all panels for the purpose of disconnecting the line from the secondary of the transformer when testing for ground or open circuit.

Short circuiting secondary plug switches are included in the equipment of panels for one transformer and two lamp circuits only and permit the operation of one lamp circuit when the other is shut down.

The panels are Blue Vermont Marble, 1½ in. thick with ⅜ in. bevel, and are mounted on a self-supporting framework of 1 in. pipe 64 in. high.

Instruments and meters have a dull black finish while the supporting framework is black japanned.

Lighting Arresters

The proper selection and installation of the lightning arrester equipment is an important feature of any series incandescent installation. As many central stations suffer enormous losses each year resulting from lightning, a horn type arrester with series resistances is recommended for the protection of the series circuits. Lighting circuits are usually confined to city limits, consequently the principal sources of trouble are not the high frequency disturbances but low frequency surges set up by sudden opening the loaded circuits. These disturbances are specially severe when circuits are accidentally grounded due to contact of the wires where they pass through the tops of trees or become crossed with other circuits.

The horn type arrester is most satisfactory for this service as the surge set up by the sudden opening of the circuit is dissipated by the arrester before the arc is interrupted. The arc usually lasts for several cycles as the operation of the arrester depends upon the lengthening of the arc, limited by the series resistance. The resistance aids the horns in extinguishing the arc, limits the size of the arc and prevents short circuits occurring during the period of discharge.

It is recommended that these arresters be installed in the station on each outgoing line and that particular attention be given to connections, especially those to ground.

Subway Transformers

The subway transformer is manufactured for the purpose of putting in subways, manholes and other very damp places where other transformers would be unable to stand the dampness. The connections are the same as for any other transformer and may be used on lighting and power circuits. It has the general appearance of the ordinary transformer although coils of a special construction are used in its design.

The following advantages are possessed by this special transformer in addition to the many advantages inherent in all transformers:

1. An improved type of bushing, allowing the trans-

former to be connected to the line without removing the cover.

2. A tank constructed to give extra radiating surface.

3. An improved gasket between the cover and the case to keep out moisture.

4. A special designed relief plug which protects the tank from undue stress resulting from short circuits on the secondary or other abnormal operating conditions.

5. The same plug allows the tank to be filled without removing the cover.

Emergency Connections—Scott System

In case of trouble and if it is absolutely necessary to have the phase changing apparatus in operation when one of the regular transformers is out of commission the situation can be taken care of by using two transformers whose ratios are 10 to 1 and 9 to 1 and connect one lead from the one that has the 9 to 1 ratio to the center point of the one having the 10 to 1 ratio. This connection causes a small phase displacement and an unsymmetrical voltage balance, that is the voltage across any two phases is not exactly equal, but it is all right for power connections and is better than a shut down. It is recommended for emergency purposes only.

Transformer Troubles

The subject of transformer troubles may be divided into two parts; first, troubles that arise before they are in operation and second, those that occur after they are in operation.

The single phase transformer, as it comes from the manufacturer, is supposed to be ready to connect and operate at full load without an undue temperature rise as they are tested before being shipped. The leads from both secondary coils are supposed to be brought out so they have the same instantaneous polarity, but it happens, once in a great while, that they are not and then all apparatus connected to it will appear to be short-circuited. In such a case the only change necessary is to reverse one set of the secondary leads. The trouble mentioned above always manifests itself by blowing out the primary fuse as soon as the current is thrown on, or by opening the automatic switch if fuses are not used. It is necessary to phase out all three phase transformers before parallel operation can take place and it should be remembered that a star connection and a delta connection will not operate in parallel when supplied from the same primaries. Cases have happened where it was necessary to operate single phase transformers of different makes on three phase work. In such cases some other voltage would be obtained although all were of the same ratio. This is caused by the leads being brought out so that they give opposite instantaneous polarity which would give a star voltage even though a delta connection were made. This can be corrected by reversing the secondary leads which show the wrong voltage, or if the polarity is right the internal resistances and reactances may prevent parallel operation.

Operating Troubles

Troubles that occur after operating conditions start are, as a rule, caused by poor cooling, abnormal load and voltage, or from improper load connections. Conditions that result in abnormal temperatures should be guarded against, and where they cannot be eliminated entirely, it is often possible to offset some of the objections by proper attention. In water cooled transformers the temperature of the cooling water may be too high, or the amount of water may not be sufficient. Sometimes the cooling coil is attacked or lined by impurities from the cooling water in the form of a residue which restricts the flow of water. After the cooling coil has been allowed to get overheated a few times, which also allows the oil to get overheated, a deposit from the oil is formed on the cooling coil. This deposit is an excellent heat insulator and should be removed at once before conditions get worse.

After an accumulation has formed on the outside or inside of the cooling coil it may be removed from the outside by removing the coil and scraping it off. Any scale or deposit that may have formed on the inside of the cooling coil may be removed by allowing a solution of equal parts of water and hydrochloric acid to stand about an hour in the coil after siphoning the old water out. This will generally remove the scale. Then the coil can be flushed and replaced in the transformer and reconnected.

When transformers are located in cool places, condensation of moisture on the inside surfaces causes trouble. This may be avoided by operating the transformer at a temperature of 35 deg. to 40 deg. centigrade, which will store enough heat in the transformer to keep it warm when not in operation—during which period the water should be shut off.

Air blast transformers often run hot on account of the air ducts becoming clogged with dirt. Often times this can be easily remedied by reversing the air circuit for a few minutes and then using a higher air pressure to clean the ducts. With the air blast transformers, great care must be exercised, when making soldered connections with the blow-torch, not to let the flame get in contact with the coils which are open at the bottom. If a flame gets started it is almost impossible to put it out before serious damage has been done to the transformer. Cases are on record where banks of this type of transformer have been entirely destroyed by careless workmen taking a supply of gasoline under the transformer to work and carelessly let it explode.

In distributing systems where the alternator is a star wound machine it has been found profitable to ground the neutral point thus making it possible to obtain a single phase current from any of the leads to the ground. This neutral is carried out to where the current is used and, as the generators are usually of a high voltage, transformers are connected to one lead and the neutral to supply current for lighting purposes. Some trouble has been experienced by grounds on this system and from the circulation of heavy no-load currents that circulate on transformers that are connected for three phase loads.

A case of trouble that often puzzles the operator is what to do in case one of the transformers burns out. Suppose, for an example, the primaries at the power station are connected delta and the secondaries are connected star (grounded) and all along the transmission line there are several sub-stations that have transformers connected with the primaries star and the secondaries delta. If one of the power house transformers burned out, what would be the proper way to handle the trouble, without making many changes at the sub-stations and as few at the power station as possible? Answer—The burnt out transformer should be removed from the circuit, and the conductor of the transmission line left inactive should be connected at the power house to the neutral of the secondary side of the two remaining transformers and, at the sub-stations, it should be connected to the primary side of the sub-station transformer banks. This would reduce the rated capacity of each bank to 57 per cent and the transformers at the power station would still produce 86 per cent of their rated capacity. The line connected to the neutral would carry a current 73 per cent higher than the other two.

Current Transformer Troubles

The troubles that are common to current transformers are few. Should the insulation on the primary side break down so as to cause a ground, the transformer should be removed and replaced with another. If the secondary circuit is left open a very high voltage will be generated in the coil which will soon burn the coil out.

An emergency connection for a current transformer is to put a jumper on the primary terminals (while dead) until it can be replaced with another. There are cases on record where current transformers have burned out and no others like them, that is of equal capacity and ratio, were on hand to replace them. For example, suppose a line was carrying 800 amperes through a 160 to 1 ratio transformer and those held as extra were of only 400 ampere capacity with a ratio of 80 to 1. In this case two of the 400 ampere transformers could be used by connecting the primaries in multiple or parallel and by connecting the secondary leads in series through the circuit.

Questions on Transformers

The following list of questions are for general practice for those not entirely familiar with the practical operation of transformers:

1. What is the object of the transformer?
2. What one condition must be fully met in its design?
3. Name several points the designer must keep in mind while designing?
4. Name the three principal parts of a transformer?
5. How many coils have most transformers? Name them.
6. Why is insulating material often used between the laminations?
7. What is transil oil used for?
8. Name several types of transformers.
9. About how much air pressure is used on air blast transformers?
10. Where are the connections made in this type?
11. How would you dry transil oil?
12. Where are the primary connections of the coils generally made on small transformers?
13. Where are the secondary connections made?
14. Suppose the name plate said that "Primary voltage 3,300 to 6,600 volts, secondary volts 110 to 220 volts" and you wanted to use the full capacity of the transformer on a 3,300 volt feeder and supply lights at 110 volts from a three wire secondary. Draw a diagram inserting voltages across terminals of each of the coils.
15. What is meant by core loss? Copper loss?
16. What is the use of a primary cut out?
17. What size fuse would you put in the primary circuit of a 100 k.w.a., single phase transformer with a power factor of 86 per cent and allow 100 per cent overload?
18. What would be the all-day efficiency of a 10 kw. transformer allowing 70 watts core loss and 200 watts copper loss, carrying full load for 10 hours and no-load for 14 hours?
19. If you were to choose a transformer for a power station that was to operate at 100,000 volts on a primary and 2,200 volts on the secondary side and the transformer was to carry 2,500 kw. what type of a transformer would you choose and give your reason?
20. What type has the greater fire risk?
21. In your own words explain how you would phase out two single phase transformers that were to operate in parallel.
22. What is an open delta connection?
23. If a bank of single phase transformers that have a ratio of 10 to 1 were connected with the primaries star and the secondaries delta, what would be the primary voltage if the secondary voltage was 132.9 volts?
24. If the voltage across phases is 2,300 volts and the ratio of each transformer is 40 to 1, what would be the voltage across the secondary terminals of each transformer, using a star connection?
25. What is the difference between a current transformer and a potential transformer?
26. What is the use of a constant current transformer?
27. Which is the primary coil?
28. Which is the movable coil in the one shown?
29. What would be the voltage across the secondaries of a constant current transformer if there were 70 series arc lamps connected, each taking 77 volts?
30. How many types of potential transformers are there?
31. What is the use of a current transformer? Potential transformer?
32. What is the current in the main circuit if the ammeter shows 4 amperes and the ratio of the current transformer is 60 to 1?
33. What caution should be taken about the secondary circuit of the current transformer?
34. What will cause an air blast transformer to heat? Oil insulated?
35. If the station voltage was 2,300 volts and the line loss was 23 volts, and a transformer with a 10 to 1 ratio were connected to boost the line voltage 10 per cent what would be the voltage at the end of the circuit?

New B. & O. Substation

For installation in the Curtis Bay substation at Baltimore, the Baltimore & Ohio has purchased from the Westinghouse Electric & Mfg. Company of East Pittsburgh, Pa., three 500 kw. rotary converters; three 500 kva. oil-insulated, self-cooling, 3-phase, 25-cycle, 13,200-volt high tension, rotary low tension transformers; four 50 kva., single phase, 25-cycle, 13,200, 15 50-volt transformers, and one 17-panel switchboard. This substation will supply energy to the Curtis Bay coal pier, one of the largest coal piers in the country. Energy will be furnished to the substation by the Baltimore Consolidated Gas & Electric Company.

A. B. C. Car Lighting Course

Lesson No. 53

The Stone-Franklin System

THE Stone-Franklin generator is a shunt wound machine and is made up in two different sizes—

Type 35, a two-pole machine, designed to furnish a nominal output of 1.6 kw. or 40 amperes at 40 volts.

Type 50, a four-pole machine, designed to furnish a nominal output of 3 kw. or 75 amperes at 40 volts.

The magnet frame is of high permeability cast iron and the laminated poles of the T-35, and the wrought iron poles of the T-50 are bolted to the magnet frame. The armature is form wound and the connections to the commutator are carefully protected by a special band of insulating material. All windings are impregnated with heat radiating varnish by a special vacuum method. The commutator, made up of hard-drawn copper segments and insulated with mica, is provided with a liberal wearing depth and ample area for carrying the maximum current of generator. The carbon brushes are held in box type brush holders designed to give practically an even tension throughout the wear of the brush. The mica is slightly undercut.

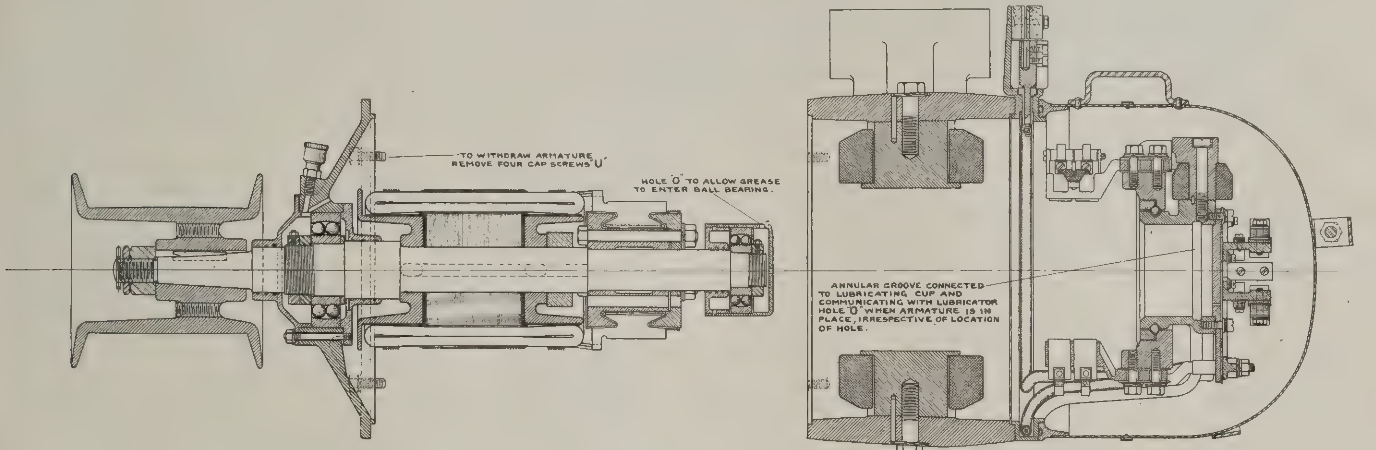

TO WITHDRAW ARMATURE REMOVE FOUR CAP SCREWS "U"
HOLE "O" TO ALLOW GREASE TO ENTER BALL BEARING.
ANNULAR GROOVE CONNECTED TO LUBRICATING CUP AND COMMUNICATING WITH LUBRICATOR HOLE "O" WHEN ARMATURE IS IN PLACE, IRRESPECTIVE OF LOCATION OF HOLE.

Fig. 1—Longitudinal Section, Showing Armature Removed from Generator

Output Control

Since the output control with the Stone-Franklin generator is effected by controlling the speed of the armature, it is not necessary to weaken the field strength at increase of train speeds, with the result that the correct magnetic relations between armature and field are always maintained regardless of train speed. This results in good commutation throughout. For this reason the Stone-Franklin generator can safely be operated with 50 to 75 per cent overload for comparatively short periods, since it will always operate under ideal electrical conditions comparable with those of generators used in stationary plants. The peripheral speed of the commutator at the highest train speeds does not exceed 1,000 ft. per minute.

The armature is fitted with self-aligning ball bearings, and in order to obviate the danger of impairing their fit on the shaft by frequent withdrawal, the commutator-end ball bearing housing has been designed so that it is self-contained on the armature. This special feature enables the maintenance man to withdraw the armature without interfering with the ball bearing at either end. The loosening of the four screws which hold the pulley end head to the yoke enables the armature to be withdrawn with both ball bearings in place as shown in Fig. 1. Lubricating cups are fitted to each bearing in order to enable fresh grease to be forced into the bearings when needed.

Dust Cover

A special feature is embodied in the method of applying the commutator-end dust cover, as shown in Fig. 2. This pressed steel dome is held by a strap eccentrically fitted in relation to the radius of the dome itself so that a wedging effect is obtained by forcing the strap down. No tools of any description are required to remove this cover.

Pole Changer

Since the Stone-Franklin machine is an ordinary shunt wound generator it is, of course, necessary to provide a pole changer. The design of this part of the machine is unique in that it provides a protection for the armature against currents from the battery when the machine is inoperative.

The collecting carbon brushes are mounted on a brush rocker which is free to move about 10 degrees in the direction of the armature rotation, the initial movement of the brush rocker being facilitated by the use of ball bearings. The extension contact arms D and E (see Fig. 3), which are attached to the brush rocker, carry the armature current from the carbon brushes to the pole changer brushes on the little switchboard in front of the machine. When the armature starts to rotate these extension contact arms are brought, first, into contact with the small pair of brushes F and G, known as the excitation brushes. This initial movement of the rocker is imparted, first of all, by the friction of the carbon brushes on the commutator. The field coils W, and the clutch coil H, Fig. 4, are so connected that the armature voltage is impressed on them as soon as the contact arms D and E make contact with the excitation brushes. The generator voltage can now build up and the electro magnetic force exerted on the magnetic clutch C, Fig. 3, completes the movement of the brush rocker and connects the extension arms to the main brushes J and K of the pole changer, as shown in third photograph of Fig. 3. The connections are now made for the machine to furnish current to the external circuit in the proper direction.

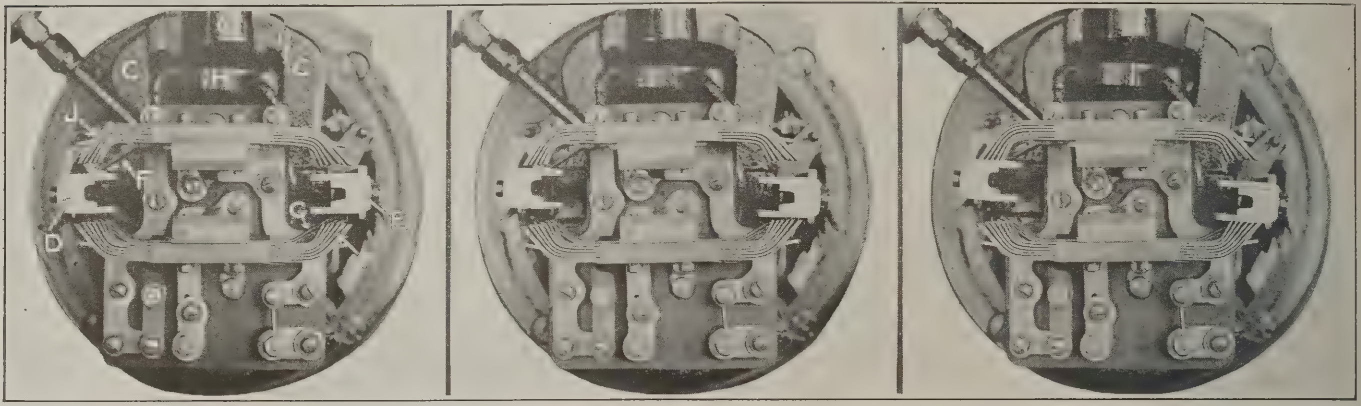
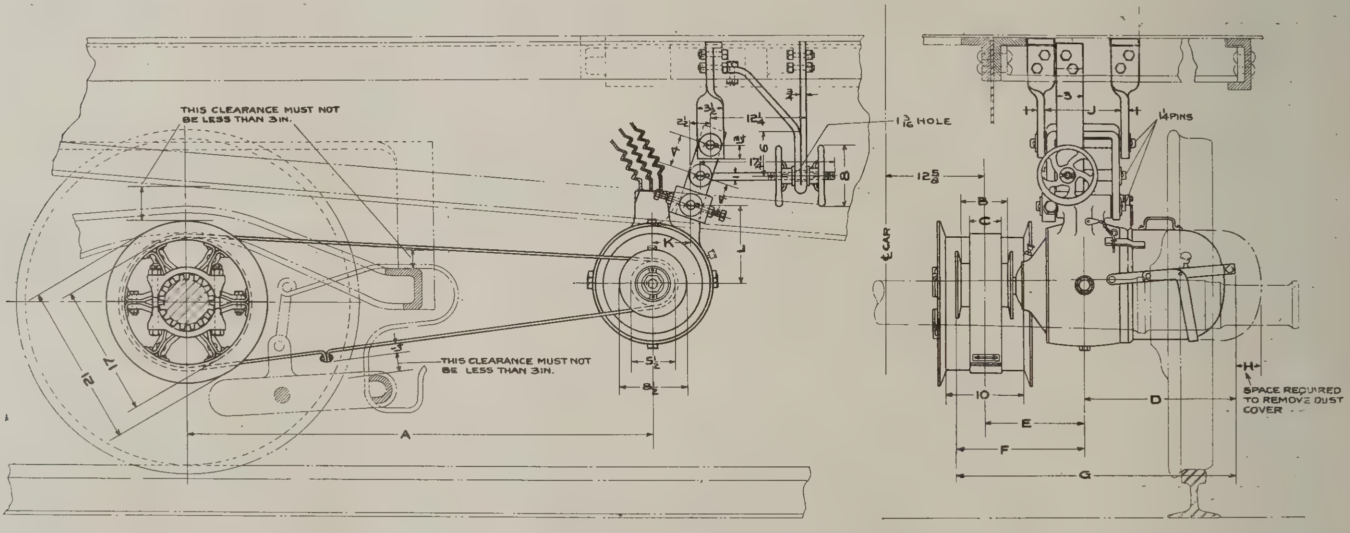


Fig. 3—Three views of the pole changer showing successive stages in its operation. The first view shows the position of the contact arms D and E, which are connected to the brushes, when the generator is at rest and inoperative. When the armature starts to revolve the friction of the brushes on the commutator moves the contact arms in the same direction until they make contact with excitation brushes F and G, allowing the generator voltage to build up. At 20 volts the clutch coil H pulls the clutch arms C to the right, which causes the contact arms D and E to make contact with the main contacts J and K.

This magnetic clutch is designed to complete the full movement of the rocker at 20 volts, which insures the closing of the pole changer before the automatic cut-in switch connects the generator to the battery. The construction of the pole changer switches is so arranged that a wiping contact is provided and the clutch coil holds the rocker in position throughout the operation of the generator with a force of approximately 36 pounds.

Referring back to the first photograph in Fig. 3, which shows the pole changer with the armature stationary, it can be seen that the extension contact arms are not in contact with the main brushes and ordinarily, with the machine at rest, are not even in contact with the excitation brushes. If, however, the extension arms should rest against the excitation brushes, the armature is still protected from any battery currents resulting from an untimely closing of the cut-in switch, since the negative excitation brush at the bottom of the pole changer is insulated from the negative main brush.

When the armature slows down, the clutch coil will hold the rocker in position until the machine becomes stationary, at which time the tension of the excitation brushes will force the contact arms free from the main brushes, thereby giving the armature full protection from a rush of current from the battery due to an untimely closing of automatic cut-in and out switch. When the machine reverses, the friction of the carbon brushes on


THIS CLEARANCE MUST NOT BE LESS THAN 3IN.
THIS CLEARANCE MUST NOT BE LESS THAN 3IN.
1 3/16 HOLE
12 5/8
1/4 PINS
℄ CAR
SPACE REQUIRED TO REMOVE DUST COVER
A
B
C
D
E
F
G
H
J
K
L
10
17
12
5 1/2
8 1/2

Type	A Ft. In.	B In.	C In.	D In.	E In.	F In.	G In.	H In.	J In.	K In.	L In.
35-F.....	4—6	6½	3	16 13/16	11 11/16	15⅝	32 7/16	9	6 13/16	2¾	9⅛
50-F.....	5—0	7	4	19 3/16	13½	17 11/16	36⅞	10	9 5/16	5	10

NOTE: Above application shows a left hand generator. Generators are furnished either right or left hand as required by builders or railroad company. A left hand generator is one having pulley on left side, looking from generator toward driving pulley on car axle.

Fig. 5—General Application of Generator Suspension and Axle Pulley

the commutator will, of course, move the rocker in the direction of the armature rotation and since the sines of the contact arms reverse, the correct armature polarity will be brought to the proper brushes on the pole changer switchboard. In this way the current from the generator is kept in a uniform direction regardless of direction of armature rotation.

Motoring Terminals

To make it possible for one man to motor the machine and at the same time observe the commutator while the machine is operating, a pair of motoring terminals are fitted close to the generator on the car body. By pulling the movable arms of clutch C, Fig. 3, over in one direction and bridging the motoring terminals, the machine can be motored. After the armature has run up to full speed the clutch will, of course, hold the rocker in position until the motoring terminals are disconnected. To rotate the armature in the opposite direction, the clutch is pulled in the direction in which it is desired to run the armature and the bridge terminals short circuited. Before motoring, however, the belt must be removed, and since there are no tension springs employed with the Stone-Franklin generators, this is readily accomplished by pushing the machine towards the axle pulley.

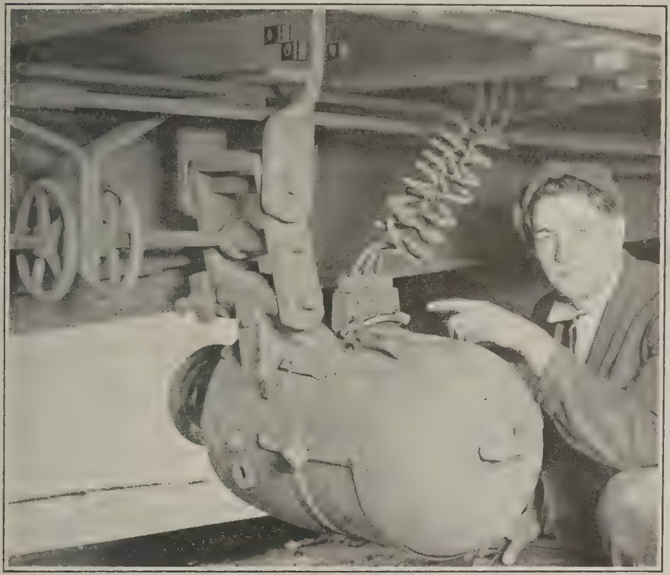


Fig. 2—View of a Stone-Franklin Generator Showing Method of Suspension. The Man Is Pointing to the Output Indicator

Generator Suspension

The generator is suspended from the underframe of the car by an adjustable, alinable link (see Fig. 5). This link allows the point of suspension of the dynamo to move towards or away from the driving pulley on the axle. The tension screw T, Fig. 6, serves to regulate the belt tension, which is readily translated into terms of output by the output indicator on the commutator end of the machine.

The output indicator, which is based on the principle of a spirit level, indicates primarily the angular position of the generator and is calibrated accordingly into terms of amperes. By means of screws P, Fig. 6, in the adjustment bracket, the generator can readily be lined up in order to allow the belt to run in the center of pulleys. The correct position of the link is 2 in. out of the vertical towards the driving axle pulley.

This simple type of suspension insures free access to the machine and is readily applied to any car body. The suspension lug of the generator is provided with an oil hole, through which the suspension link should be lubricated periodically.

The auxiliary apparatus used in connection with the Stone-Franklin equipment consists of an automatic cut-in and out switch and a battery change-over switch, as well as main and field fuses. The mounting of this apparatus on the panel is shown in Fig. 7. The wiring diagram is shown in Fig. 8.

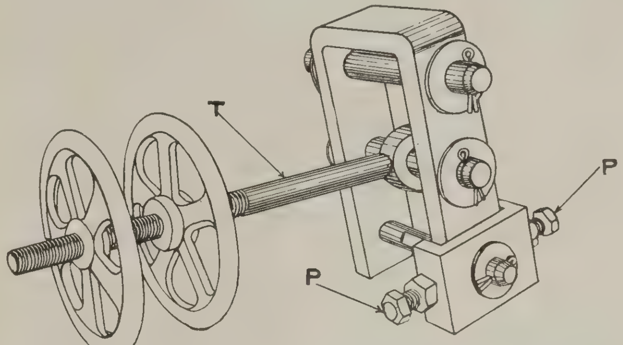


Fig. 6—Suspension Link Showing Adjusting Screws P for Paralleling Generator Shaft with Driving Axle

Automatic Switch

The automatic cut-in and out switch is fitted with a shunt coil which serves to lift the plunger with its laminated brush at a predetermined general voltage, thus closing the circuit between the armature and batteries. A series coil further assists the lifting power of the shunt coil after the switch is closed and insures a good contact.

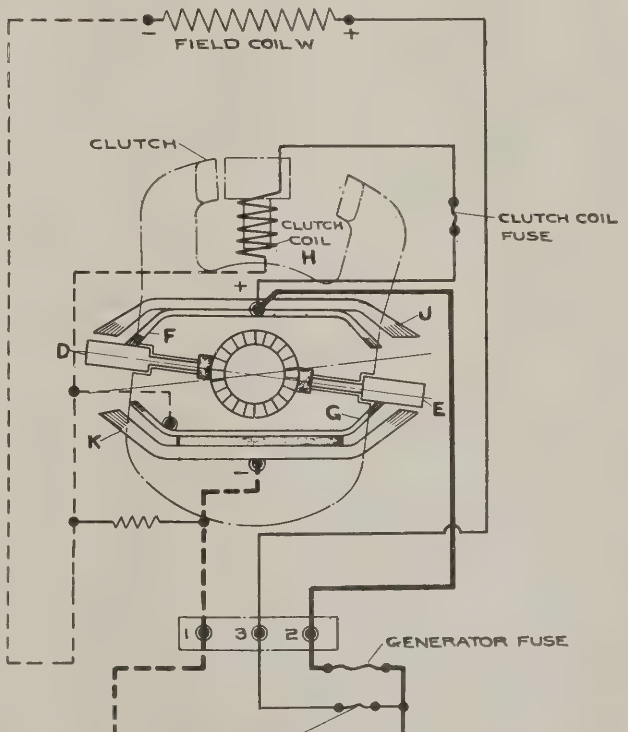


Fig. 4—Schematic Diagram of the Pole Changer

A shunt across the series coil is so connected that the latter will only carry approximately 50 per cent of the generator current.

The specially designed magnetic circuit of this switch insures the reliable making and breaking of the circuit at the correct moment without interfering with the strength of the shunt coil. Arcing at the cut-in and out switch is, therefore, practically eliminated, since half an ampere of reverse current from the battery will throw the switch out. This is effected by the following simple patented arrangement in the design of the magnetic circuit: The electro motive force created by the shunt coil is practically used up in forcing the flux through the air gap in the plunger. It is, therefore, very apparent that with this air gap closed and the switch in the "up" position, only a small magneto motive force is required to hold the plunger in this position and consequently a considerable demagnetizing force would have to be applied in order to release it. If, however, a second air gap which compensates for the closing of the top air gap is introduced at the bottom of the plunger when it is in the "up" position, it is evident that with such an arrangement of the magnetic circuit it is possible, by proportioning the two air gaps in the correct ratio, to have a magnetic switch which will operate at the difference of potential between opening and closing voltage, which is about one volt. It is now readily seen that only a small demagnetizing force has to be applied in order to release the plunger. This method eliminates the weakening of

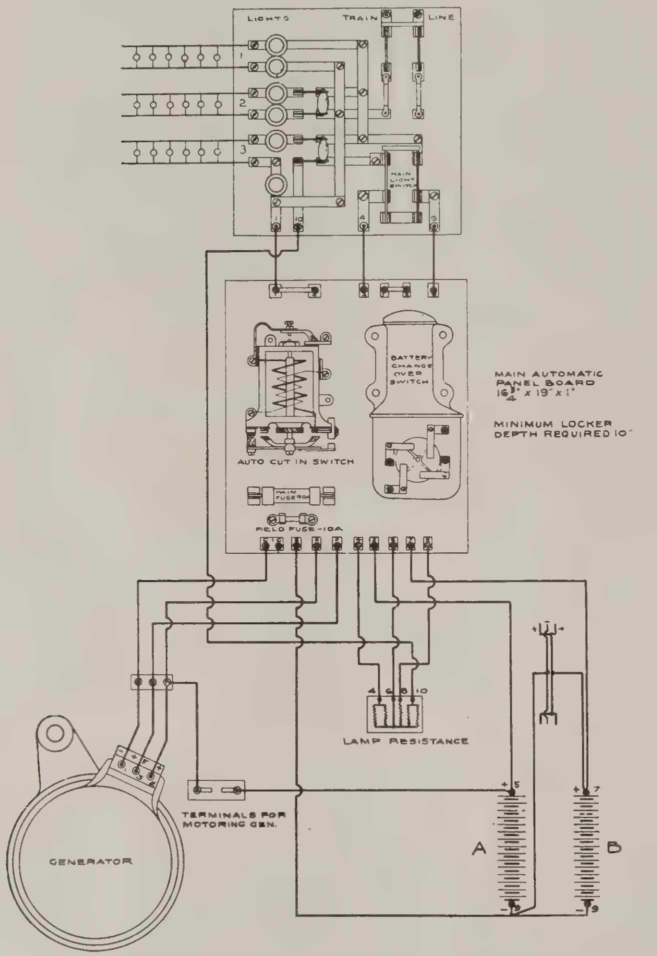

LIGHTS
TRAIN LINE
1
2
3
MAIN LIGHT SWITCH
BATTERY CHANGE OVER SWITCH
AUTO CUT IN SWITCH
MAIN FUSE
FIELD FUSE-10A
MAIN AUTOMATIC PANEL BOARD 16¾" x 19" x 1"
MINIMUM LOCKER DEPTH REQUIRED 10"
4 6 8 10
LAMP RESISTANCE
TERMINALS FOR MOTORING GEN.
GENERATOR
A
B
+ 5
+ 7
- 9

Fig. 7—Connection Diagram for Stone-Franklin Car Lighting Panels

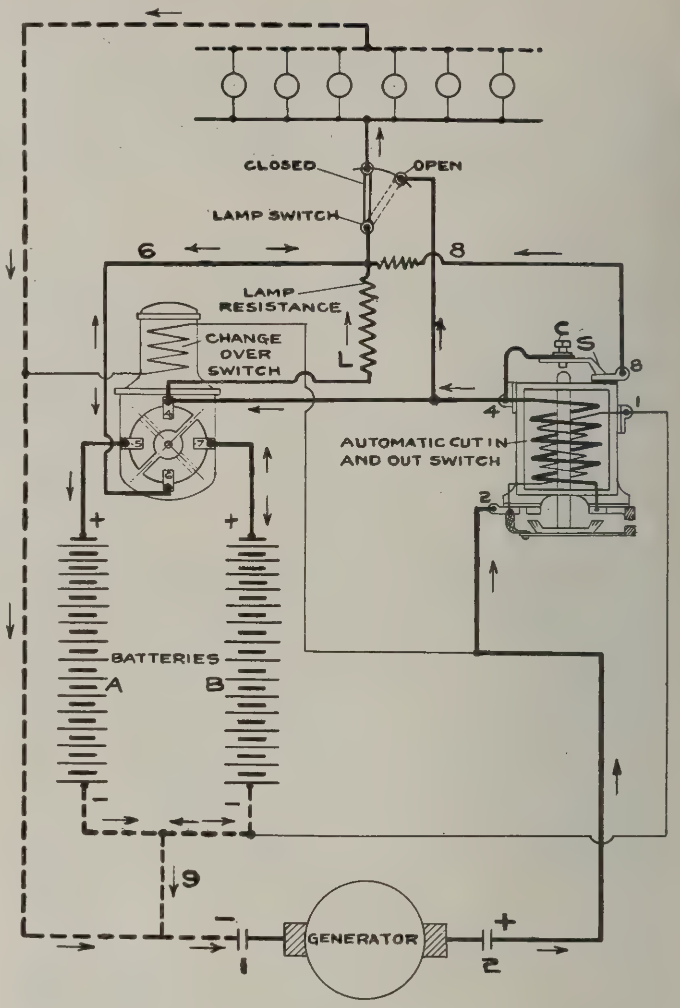


Fig. 8—Schematic Wiring Diagram of the Stone-Franklin Equipment

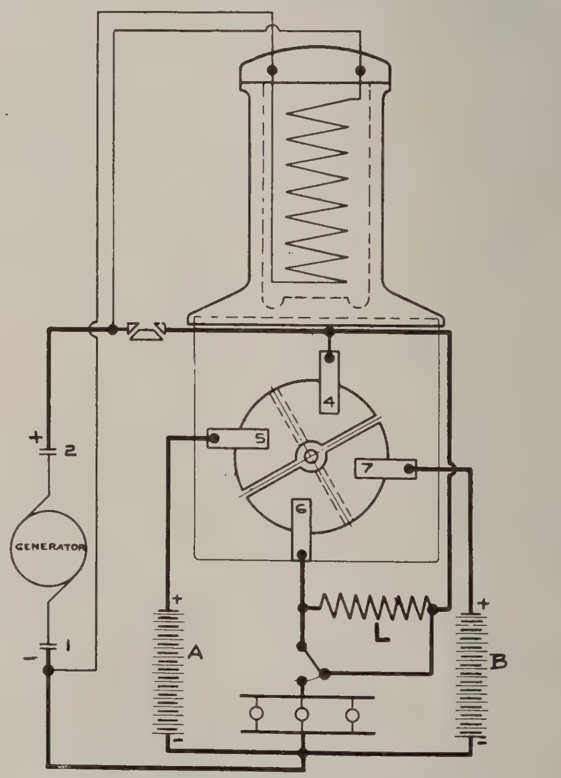


Fig. 9—Schematic Wiring Diagram of Battery Change Over Switch

shunt coils by auxiliary switching actions and furthermore insures that the switch will reliably open with a minimum of back current from the batteries, in this case amounting usually to about one-half ampere.

Battery Change-Over Switch

The battery change-over switch, the function of which was described in the preceding lesson in the June issue, consists of a solenoid actuating a gravity-held plunger, and a circular disc divided by a diametrically placed strip of insulation into two equal sections, each in contact with two laminated brushes Nos. 4 and 5, and 6 and 7 (see Fig. 9). The solenoid of the battery change-over switch is connected across the brushes of the generator so that each time the generator builds up its voltage the plunger is drawn up and in so doing effects a turn of 90 degrees on the contact disc.

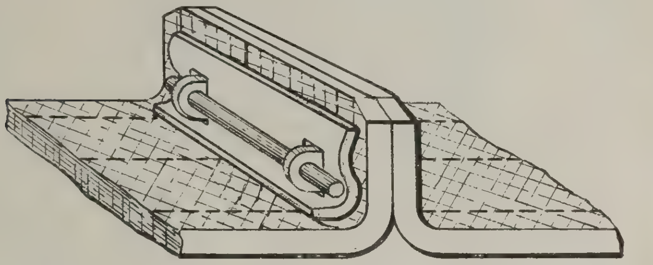


Fig. 10—The Walker Belt Fastener Used with Stone-Franklin Car Lighting Equipments

Referring again to Fig. 9 it can readily be seen that the dynamo current enters the contact disc at brush No. 4, allowing the current to be conducted to brush No. 5, which in turn is connected to battery "A" which, therefore, gets a charge. Brush No. 6, connected to positive lights, is also electrically connected by the contact disc, through brush No. 7, to the second battery "B," which under these conditions serves to keep the lamp voltage constant. A 90 degree rotary turn of the disc automatically connects brushes Nos. 2, 4 and 7, and 5 and 6, or in other words, the battery last charged will now back up the lamp voltage and the battery which has previously been connected to the lamps will now be connected to the generator and thus receives a charge. This apparatus makes it possible to insure that both batteries receive equal amounts of charge and further insures that a charged battery is always connected across the lamps for the purpose of stabilizing the lamp voltage. A main light switchboard is furnished with the Stone-Franklin equipment as shown in Fig. 7, and the feature of interest is the main light switch, which in the "off" position parallels the batteries by short circuiting the lamp resistance through contacts Nos. 6 and 4. Any number of circuits can be arranged for, according to the railroad's specification.

Lamp Resistances

The lamp resistances are fitted in an expanded iron case which is usually placed in the locker with the automatic panel board.

Belts

The belts used with the Stone-Franklin car lighting generators are four ply with the following widths:

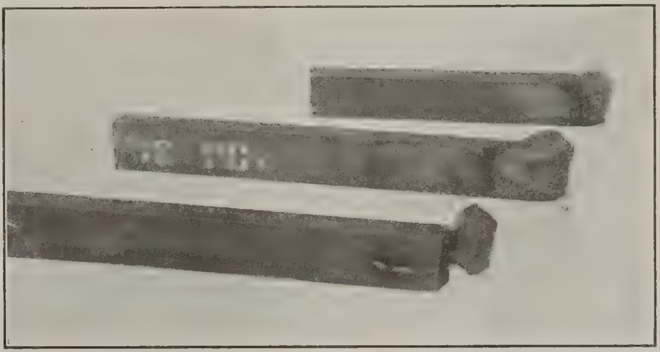
Type 35, 1.6 kw.	2½ in.
Type 50, 3 kw.	4 in.

When applying a new belt, great care must be taken to insure that the ends of the belt are cut square and are fitted together perfectly. Only Walker fasteners, as shown in Fig. 10, should be used.

The maintenance of this equipment will be taken up in the next lesson.

Arc Welded Cutting Tools

With the present price of high speed tool steel it has been found economical to build up cutting tools with a small piece of high speed tool steel electrically welded onto a shank of ordinary tool steel. The Westinghouse Electric & Manufacturing Company, of Pittsburgh, have been very active in this development and the process by which the tools are made is clearly shown in the illustrations. This company states that by means of arc welding their cutting tool tips they have been able to build up a more solid shank which has given more satisfactory results and at a considerably cheaper price than by any other process. This conclusion has been reached after exhaustive tests employing oxyacetylene, incandescent electric (butt welding) and forging methods.



High Speed Tips Welded on Common Tool Steel, Showing the Three Successive Stages in Building Up the Tool.

For best results the current used for this work is approximately 100 amperes and the voltage of the welding circuit approximately 60 to 70 volts. A 5/32 in. Norway iron electrode is used. The tools are preheated before welding, and annealed by being buried over night in mica dust or lime. They are then put through a process of heat treatment which improves their cutting qualities.

The results with this built-up cutting tool are very satisfactory, as shown by a sample lathe tool at this company's exhibit, which cut 104—4½ in. .60 carbon steel cylinders, 14 in. long at a cutting speed of 57 ft. per minute with a cut of ¼ in. and a feed of .047 in. per rev.

An accurate record has been kept of this welding work and it shows that electrically welded tools will actually produce 10 per cent more work than solid tools before regrinding is required. This is believed to be due to the reinforcing metal which is built out and around the tip, serving both to give large radiating surface and to afford a larger heat conducting path back to the butt of the tool, thus keeping down temperature at the cutting edge. At present practically all the tools for the lathes and planers used by the Westinghouse company are made in this way.

The composition of the high speed steel is comparatively unimportant as nearly all commercial brands are being welded successfully. The records on this type of welding show that so long as high speed tool steel costs over $1.25 per lb. it will be economy to weld tips on cutting tools.

The LaRock Pipe Wrench

A pipe wrench of special design and particularly fitted for working pipe where the clearances are limited, has recently been placed on the market by the Mechanical Specialties Company, Peoples Gas Building, Chicago, Ill. This wrench, known as the LaRock, should be of interest to railroad electrical men, as it is especially adapted for conduit work in electric lighting cars, buildings, power plants, etc. The construction of this wrench and its application to a pipe are shown in the drawings. It will be noticed that the tongs bear on two-thirds of the circumference of the pipe, which can be worked with a wrench motion of 10 degrees. The LaRock wrench is of simple construction, being made up of only three parts, with no screws, springs, pins or ratchets. There are no adjustments to be made and the wrench is always in position to do the work necessary. The wrench comes in four sizes, there being a special size for the ⅜-in., the ½-in., the ¾-in. and the 1-in. pipe. Although each wrench is especially fitted for its own size of pipe, it will satisfactorily work the next smaller and the next larger size. The wrench is made of high-grade drop forge steel with special steel rivets, and will stand more strain than can be applied by the man using it.

Fig 1

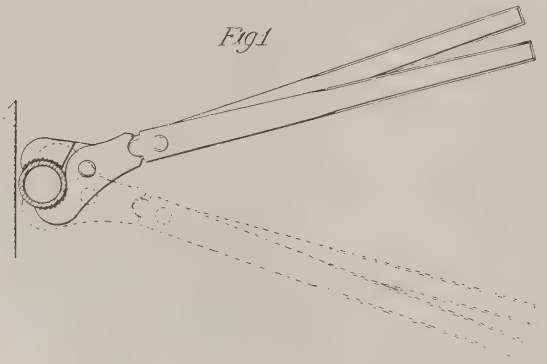


Fig 2

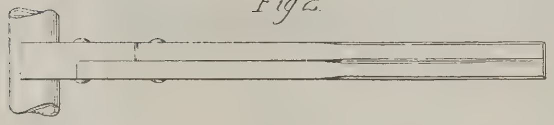


Fig 3

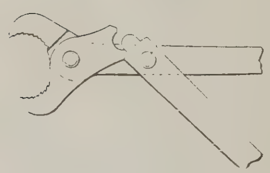
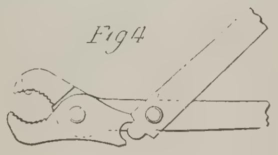


Fig 4



Emergency Lighting Unit

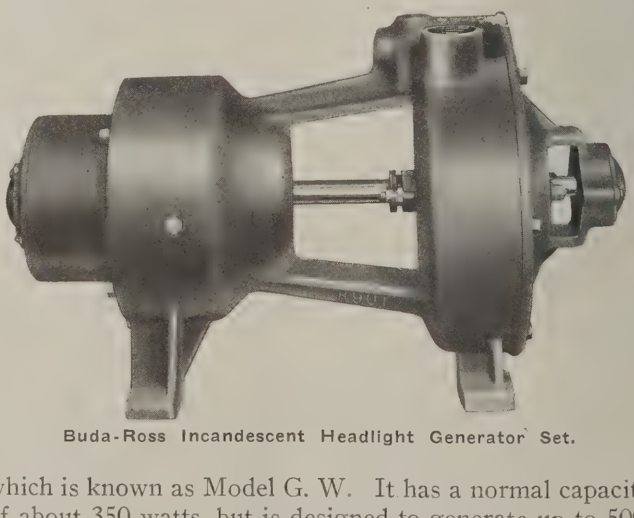
The Edison Storage Battery Company, Orange, N. J., exhibited at Atlantic City a new portable electric lamp designed for use in emergencies such as wrecks, construction work, freight congestions, etc. It is a self-contained unit, the battery consisting of five cells of the A-4, 150 ampere hour type placed in a steel box on top of which is mounted the lamp in its reflector. The lamp, which is of the 100 watt-gas filled concentrated filament type, and is fitted into a 12-in. parabolic reflector which is said to produce a reflected beam of about a million candle power. The lamp consumes 18 amperes at 6 volts and delivers 140 spherical candle power. The battery has sufficient capacity to keep the lamp burning for over 10 hours.

A thumb screw adjustable feature is provided in the lamp mounting so that the beam of light can be directed at any desired angle. Handles are mounted on each side of the box and a removable cover fitted with wing nut locks permits the quick replacement of a freshly charged battery in case continuous illumination is desired. The weight of the lamp and battery complete is about 150 lb. and the dimensions of the steel box are 14 x 14 in. and 18 in. high.

Portable Storage Battery Emergency Lighting Unit.

Buda Headlight

An incandescent electric headlight equipment was exhibited at Atlantic City by the Buda Company, Chicago, which is known as Model G. W. It has a normal capacity of about 350 watts, but is designed to generate up to 500.



Buda-Ross Incandescent Headlight Generator Set.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

A Powerful Bridge Horn

The double leaf bascule bridge shown in the accompanying photograph was built two years ago for the Canadian Pacific at Sault Ste. Marie, Mich. Both the rail and water traffic at this point are extremely heavy which requires close co-operation between the bridge operator and both the boats and the trains. To provide a suitable means of communication a powerful diaphone horn, as shown in Fig. 2, was installed on the roof of the bridge operator's tower. This horn is a low pitch instrument known as Type B and is made by the Gamewell Fire Alarm Telegraph Company of New York. It is operated by compressed air which is supplied by a Type H3 550-volt, direct current driven air compressor, regulated by a Type AR-1 automatic governor. The compressor is equipped with a reservoir 30½ in. in diameter by 96 in. long; the entire apparatus is made by the National Brake & Electric Company of Milwaukee, Wis. The horn is located about 60 ft. above ground, and during favorable weather the blasts may be heard for five miles.

A Great Lakes Freight Steamer Passing Through the Locks at the Soo

The Diaphone Horn on the Bridge Operator's Tower

J. G. Koppel,
307 South Street, Sault Ste. Marie, Mich.

Protecting Shaft Centers When Removing Dynamo Pulleys

When removing a dynamo pulley that has been on the shaft for a considerable length of time it is often found that is apparently on to stay. Ordinarily, in an effort to remove such stubborn pulleys, the heavy pressure of the puller screw, twisting around in the shaft center almost invariably damages it so that it must be re-centered in order to true the shaft to get a true commutator. To overcome this take a nut, the same size as the armature shaft, and screw a bolt into it about three threads and cut it off, then rivet it over enough to keep it in. Then take a center punch and make a center in the center of the piece left in the nut. Now screw this nut on the shaft and pull the pulleys.

H. W. Willard,
Richmond, California, Santa Fe.

Slotting Commutators

No doubt there are several good ways to slot a commutator, but in many cases the copper segments are scratched, which is often the cause of turning the commutator again in order to obtain a smooth surface for brush contact. A good way to overcome this difficulty is to take a piece of ⅛ in. sheet lead the width of the commutator and shape it to fit smooth around one-third or one-half of the commutator. Then simply straighten the top edge so that it lays perfectly straight with the mica to be cut down. You will find that it beats anything you previously tried where slotting is done by hand.

H. W. Millard,
Richmond, California. Santa Fe.

Militiamen Granted Leave of Absence.

It is announced that the Franklin Railway Supply Company has granted leave of absence to its employees already active in the Militia or those who may join later, as follows:

Married or single men with dependents, full pay and position reserved for their return.

General News Section

Pyle National Company

The manufacturers of Pyle electric headlight equipment announce that the name of the company has been changed from the Pyle-National Electric Headlight Company to the Pyle-National Company.

Arc Welding Equipments for the Pennsylvania

The Pennsylvania Lines west of Pittsburgh have purchased four 600-ampere electric arc welding equipments from the Westinghouse Electric & Mfg. Company of East Pittsburgh, Pa.

New Western Electric Executive Offices

The executive departments of the Western Electric Company, Incorporated, at New York moved on June 5 from 463 West street to new offices in the Telephone and Telegraph Building at 195 Broadway.

The move was made necessary by the steady growth of the company's engineering departments which will occupy the space that has been vacated. The change also brings the executive departments in closer touch with the heart of New York's business district.

The local New York distributing department and the engineering and patent departments remain at 463 West street.

The Headlight Order

The following order has been issued by the Interstate Commerce Commission in relation to rules 29 and 31 for the inspection and testing of steam locomotives and tenders in accordance with Act of February 17, 1911, amended March 4, 1915.

It is ordered, That the rules and instructions prescribed by the Commission's order of October 11, 1915, be, and the same are hereby, amended by the addition of the following rules:

29. *Locomotives used in road service.*—Each locomotive used in road service between sunset and sunrise shall have a headlight which will enable persons with normal vision in the cab of the locomotive, under normal weather conditions, to see a dark object the size of a man for a distance of 1,000 feet or more ahead of the locomotive; and such headlights must be maintained in good condition.

Locomotives used in road service, which are regularly required to run backward for any portion of their trip, except to pick up a detached portion of their train, or in making terminal movements, shall have on the rear a headlight which will meet the foregoing requirements.

Nothing in the foregoing rules shall prevent the use of a device whereby the light may be diminished in yards and at stations to an extent that will enable the person or persons operating the locomotive to see a dark object the size of a man for a distance of 300 feet or more ahead of the locomotive under the same conditions as set forth above.

When two or more locomotives are used in the same train, the leading locomotive only will be required to display a headlight.

31. *Locomotives used in yard service.*—Each locomotive used in yard service between sunset and sunrise shall have two headlights, one located on the front of the locomotive and one on the rear, each of which will enable persons with normal vision, in the cab of the locomotive, under normal weather conditions, to see a dark object the size of a man for a distance of 300 feet or more; and such headlights must be maintained in good condition.

It is further ordered, That said rules, 29 and 31, be, and they are hereby, made applicable to all new steam locomotives put in service subsequent to October 1, 1916, and to all steam locomotives given general overhauling subsequent to October 1, 1916, and that all steam locomotives subject to the rules be equipped in conformity therewith not later than January 1, 1920.

Personals

J. G. Cooley, manager of the railway department of the Standard Roller Bearing Company, on June 1, assumed in addition to his railway work the duties of superintendent of inspection for the same company.

Samuel M. Vauclain, vice-president of the Baldwin Locomotive Works, has been elected a director of the Westinghouse Electric & Manufacturing Company succeeding D. F. Brooker, resigned.

C. B. Woticky has been appointed electrical engineer of the Lehigh Valley and D. J. Cartwright, electrical engineer at South Bethlehem, Pa., has been appointed assistant electrical engineer. Both with offices at South Bethlehem.

C. A. Luckey has been appointed resident manager of the Edison Storage Battery Supply Company's new sales office at New Orleans. Mr. Luckey is a graduate of Franklin Military Academy, Franklin, N. Y., 1899, and Bliss Electrical School, Washington, D. C., 1900-1901. He was connected with the Western Electric Company, New York City, during 1901-1902, leaving there to go with the Safety Car Heating and Lighting Company, where he remained until 1911, spending the first four years in their electrical laboratory and then going with the Chicago branch. In 1911, Mr. Luckey was with the Railway Utility Company, Chicago. In 1912 he joined the sales force of the Edison Storage Battery Company.

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The Ninth Annual Convention

During the days from October 30 to November 3, inclusive, the Association of Railway Electrical Engineers will hold its ninth annual convention at the La Salle Hotel, Chicago. The large ballroom on the nineteenth floor of the hotel will be entirely given over to the exhibits while the convention meetings will be held in the Red Banquet Hall on the same floor.

This room in previous years has always been occupied by exhibits and the convention meetings held on one of the lower floors. It has been considered desirable, however, to concentrate all the convention activities on one floor, even at the expense of reducing the amount of exhibit space available. While this arrangement may reduce the size of many of the exhibits it will undoubtedly prove a convenience and will give the railroad men an opportunity to come in closer touch with the exhibit features of the convention than was possible with the old scheme.

Inasmuch as the time of the convention is close at hand, the chairmen of the various committees who have not yet submitted their final reports to J. A. Andreuscetti should plan to do so as soon as possible. All reports must be in the hands of the secretary not later than September 15.

Practical Stunts Competition

The primary object of a technical journal, such as the *Railway Electrical Engineer,* is to publish information that will be of practical benefit to its readers in their everyday work. With this object in view we have maintained a Practical Stunts section which has proved decidedly valuable, because the information published there is contributed by the readers who describe some useful kink or stunt that they have found particularly useful.

Every day the electrical men on the railroads are confronted with new problems and new conditions, the solution of which requires considerable thought and originality. Time and trouble saving devices are continually being developed by members of the various electrical departments. An interchange of such experiences prepares a man to meet any difficulty which may arise in connection with his work, and this is where the Practical Stunts section proves its value.

To awaken a livelier interest in this section, we should like to receive a large number of brief articles describing stunts, kinks or devices that have proved of value and which perhaps have solved perplexing problems. We don't expect elaborate essays; we don't care particularly as to whether the spelling and grammar are correct. We want the ideas—the rest can be easily taken care of.

For the best Practical Stunt article which is not more than 500 words in length and which is received at our office in the Woolworth Building, New York, on or before October 1, 1916, we will give a prize of ten dollars. For the next best Practical Stunt we will give five dollars; others which are accepted for publication will be paid for at our regular rate. Where possible the stunt should be accompanied by photographs, or drawings, or both. Rough sketches will be satisfactory as far as the drawings are concerned, as tracings can be made from them in this office. Obviously the judges will base their decision on the practical value of the device.

This competition ought to bring out a splendid lot of practical ideas. Who will send in the best one? Maybe some of those stunts that you have been using so long that they have grown old are just what the other fellows have been looking for. Send them along while you think of it.

Delay Statistics

The report of the Master Mechanics' Committee on Design, Maintenance and Operation of Electric Rolling Stock, which was presented at the Atlantic City convention and which appears on another page of this issue, emphasizes a condition that should be corrected. In regard to delay statistics, the report states that an inquiry directed to seventeen railroads using main line electric traction, disclosed the fact that, although all the roads kept statistics and records of train delays due to defects of electric equipment, no two compiled them from the same basis. On some roads a train delay of one minute or over is included in the reports, while on others only those over ten minutes are included. Some reports separate man failures, mechanical failures and electrical failures; others do not.

It seems evident that a record kept under these conditions does not give the proper information to officers in charge of the maintenance and design of electric equipment. From such records it is impossible to draw fair or useful conclusions as to the causes of delays on the various railroads. It would seem that the delay statistics are compiled by the operating department from their own standpoint without considering the needs of the mechanical department.

The committee's recommendations in regard to this matter are practical and to the point and should be adopted. It is the committee's just contention that statistics showing train delays should be compiled so as to form a basis for judging the efficiency of the equipment itself, as well as of the organization maintaining and running it. For this reason it would be necessary that the statistics show separately the delays caused by the mechanical parts, such as brake shoes, couplers and air brakes; the electrical parts such as motors, contactors, third rail and trolley wires, and delays due to man failure, such as improper proportion of motor and trailer cars, tight brake connections or a circuit breaker not closed by the motorman. A delay in each case of one minute or more should be recorded so that defective equipment and improper handling would be revealed. Allowing train delays under ten minutes to go unrecorded and unnoted is a practice which only fools the railroad permitting it.

To cover the above requirements the committee recommends that the delay records of the motive power departments show Miles per Detention for the guidance of the motive power department and Miles per Minute Detention for the use of the division superintendent. In this connection it is pointed out that delays to following trains should not be included in the motive power statistics as such records are confusing and misleading, therefore, worse than useless.

If the committee's recommendations are accepted and acted upon by the various railroads operating electrified divisions, some very useful statistics will be compiled which, when studied collectively from time to time, will point out the way to further improvements in the design and operation of electric equipment.

One of the greatest troubles with railroad records today is that, instead of being kept on a standard uniform basis so that comparison can be easily and quickly made, they are usually kept to meet local and individual needs only. This is a condition the speedy correction of which requires the conscientious effort of all those interested in standardization of design and reduction of operating and maintenance costs.

Field Control

Elsewhere in this issue appears an interesting article on field control of railway motors which is an abstract of a paper presented at a meeting of the Illinois Electric Railways Association held at Chicago on June 9, 1916. The paper traces a development of the methods of controlling the speed of a railway motor by varying the field strength, and then cites several applications of field control on heavy duty high-speed electric locomotives in main line service.

In the old days when field control was first tried out on railway motors, before the introduction of commutating poles, considerable trouble was experienced due to sparking at the brushes at the highest speed. In endeavoring to overcome this a high field pole saturation, produced by a large number of field ampere turns, was employed. Due to the use of commutating poles and other refinements, the modern motor is designed with a much weaker field strength, so that withour present railway motors the principle of field control can be used with entire satisfaction.

It is interesting to note that forty-one New York, New Haven & Hartford passenger locomotives, which are equipped with field control motors, have been in operation for the last ten years, during which time they have given very satisfactory service. The largest motors in existence which employ this method of control are those on the direct-current Pennsylvania Railroad locomotives.

The saving in rheostat losses effected by this method of control is forty-five per cent of the energy during acceleration which would be consumed without field control, and at 20,000 lb. tractive effort per locomotive the change from full field to short field increases the speed thirty-seven per cent. It is seen, therefore, that the field control motor combines the slow-speed high tractive effort motor which is the most economical in accelerating, with the higher speed motor which permits maintaining a higher schedule speed.

It is estimated that the total annual saving effected by the use of the field control motor is approximately one-third of a million dollars per year and, on the average, it can be said that the use of the field control method results in an approximate saving of ten per cent in operating cost as compared with the cost of a motor without field control.

In this day when it is so important to economize and reduce operating expenses to a minimum, the advantage of using field control in electric traction motors, when possible, should not be overlooked. In many cases it would be advisable to scrap the older motors in favor of the modern type.

Field Control of Railway Motors*

By D. C. Hershberger

THE method of controlling the speed of a railway motor by varying the field strength is as old as the art of practical railway motor construction. Many of the early railway motors of various makes employed the field control feature, though the term "field control" was not adopted until about ten years ago. About 1888 to 1890 the Sprague Company was building double reduction geared motors having three separate field coils per pole. These motors rated from 15 to 25 h. p. With the high resistance obtained by connecting the three coils in series, it was possible, with some of the smaller motors, to eliminate resistors. The coils were arranged in series parallel groups on the intermediate notches, while on the last notch all coils were connected in parallel.

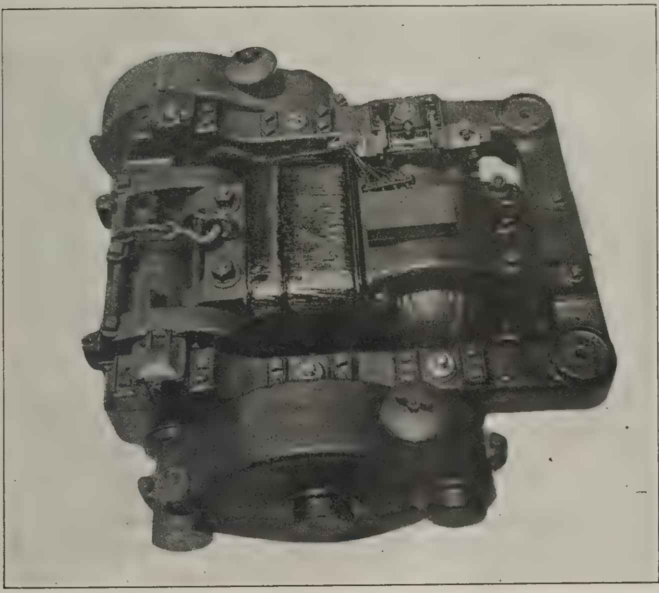

Fig. 1—Early Type of Field Control Motor, Known as Westinghouse No. 1. Note the Two Field Coils.

A year or two later there were a few motors which employed the "loop" system which was similar to the present method of field control. To obtain the higher speeds, a part of the field was cut out of the circuit, while the remaining section carried the same current as the armature. This required a winding having a larger cross section than that used with the former systems which connected the coils in series, series parallel, and parallel. Practically all of the equipments of this period employed rheostatic control without series paralleling of the motors.

The first Westinghouse series motor, known as No. 1, and which was designed and tested early in 1890, was essentially a field control motor. A view of this motor is shown in Fig. 1. The field was wound with two sets of coils and speed regulation was obtained by the sectional field method in which two coils were in series for lowest speed and one coil was short circuited for increased speed. The control system used with these motors was straight rheostatic, except the short circuiting of one field winding for high speed. The armatures were connected permanently in parallel and the field windings of the different motors were also in parallel.

Rheostatic control was soon superseded by series parallel control which was put on the market shortly after the first of these motors were put in service. The reduction of the losses in starting affected by this type of controller tended towards the abandonment of field control. Troubles due to poor commutation and overloading of motors still further tended toward the abandonment of the method of controlling the speed by varying the field strength. A period of about 15 years then elapsed before field control was applied to locomotives, and 20 years before it was again applied to car equipments. The introduction of the commutating pole motor, the general improvement in railway motor design, and a better understanding of motor application led to a revival of this method of control.

Modern Applications

The next application of field control was made in 1906 on the A.C.-D.C. passenger locomotives for the New York, New Haven & Hartford. One of the locomotives is shown in Fig. 2. They are equipped with four 250 h. p. motors which are of the gearless type. The full field may be used or either of two higher speeds be obtained by shunting part of the field current through a grid resistor of low ohmic value when operating from direct current supply. Forty-one of these locomotives have been in operation for the last 10 years and have given very satisfactory service.

The giant motors, shown in Fig. 3, of the Pennsylvania Railroad locomotives stand out as a remarkable application of field control. To date, they are the largest motors in existence employing this method of control. Each motor weighs approximately 44,000 lb. and is capable of developing 2,000 h. p. They are different from the New Haven motors, in that instead of shunting the field, half of it is cut out on the final notches in series and parallel. On notches between full field and short field, a part of the field current is shunted through a resistor. Series parallel control is used, which, with the field control feature, permits eight efficient running positions. Such a large saving in rheostatic losses is effected that during acceleration the energy consumption is reduced to 55 per cent of what it would be without field control. At 20,000 lb. tractive effort per locomotive the change from full field to short field increases the speed 37 per cent. Thirty-three of these locomotives have been in service in the New York Terminal zone since 1910, giving most excellent satisfaction, and one of them was awarded the Grand Prize at the Panama-Pacific International Exposition.

Test Results

In the latter part of 1910, H. H. Adams, of the Metropolitan Street Railway Company, New York, was investigating car designs relative to reducing operating costs by the use of lighter weight cars and more economical motor equipments. At a conference between Mr. Adams and N. W. Storer it was decided that field control motors be tried out, as it was anticipated the saving in energy consumption would be approximately 10 per cent. Under Mr. Adams' direction, a double equipment of No. 307-C3 motors was given a thorough test in 1911 in New York service. This installation marked the first application of modern field control to city service.

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*Abstract of a paper presented at a meeting of the Illinois Electric Railways Association held in Chicago, on June 9, 1916. Mr. Hershberger is electrical engineer, General Engineering Division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

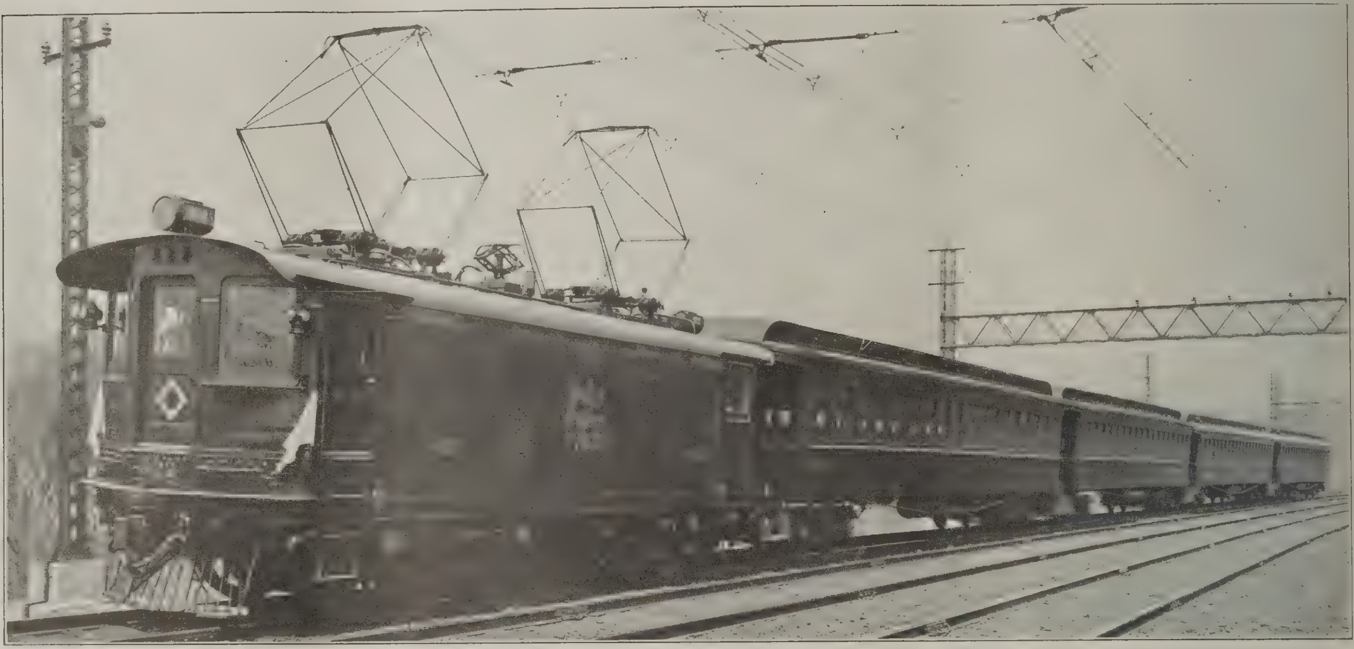

Fig. 2—New Haven Electric Locomotive with Field Control Motors.

The results of these tests, shown on table No. 1, indicate clearly the economies made possible by field control.

TABLE I.

Test number:	Wt. of loaded car, tons	Motor	R.p.m. 40 hp.	Gear ratio	Stops per mile	Slow downs per mile	Av. length of stop, seconds	Schedule speed, m.p.h.	Ave. volts	Watt-hr. per ton-mile
1	20.214	Standard 60-hp....	560	4.6	6.975	2.86	8.503	7.126	557	152.26
*2	19.729	Standard 40-hp....	550	5.12	6.778	3.08	7.765	7.261	556	141.63
†3	20.153	Field control, 40-hp.	445	5.12	8.333	3.11	7.240	7.142	551	133.85
4	19.714	Field control, 40-hp.	445	5.12	6.881	3.56	7.335	7.409	555	124.41

*Normal field on field control motor.
†In congested district ran in series only.

Comparing Tests 1 and 2, it will be observed that by reason of a slower speed armature and greater gear reduction an energy saving of 7 per cent was effected. With 20 per cent more stops in Test No. 3 than in No. 1, the saving was 12 per cent, due to field control and larger gear reduction. In Test No. 3, the equipments were operated in series throughout the congested district, and in series parallel on the remainder of the trip. Even though this test showed 23 per cent more stops than Test No. 2, the energy saving was 5.5 per cent. This saving was due to field control entirely. In Test No. 4, the number of stops and other service conditions were about the same as in Tests 1 and 2, but the motors were operated making full use of field control in both series and parallel over the whole line. This test showed 7 per cent less energy consumption than Test No. 3 with its greater number of stops and 12 per cent less than Test No. 2, with practically the same service conditions. It will be noted that the temperature rise on the 60 h. p. motors in Test No. 1 was approximately 48 deg. C., while on the 40 h. p. field control motors in Test No. 4 it was only 58 deg, C., which is a perfectly safe operating temperature.

In Chicago, modern field control motors were first put in service in 1913 on both the Elevated and Surface Lines, due to the efforts of H. H. Adams, Superintendent of Shops and Equipment of the Chicago Surface Lines, and H. A. Johnson, Master Mechanic of the Chicago Elevated Railways. Practically all subsequent equipment installations have been field control.

Principles of Field Control

It may be worth our time to delve into the principles of modern field control to get a clearer understanding of its performance and field of application.

The torque of a motor is approximately proportional to the product of the field strength in induction and armature ampere turns. Altering the field strength offers the best opportunity for torque and speed variation with a given motor. At present, the cheapest and simplest field control equipment for cars, including motors and control, can be obtained by the use of two electrically separate field coils per pole. These coils are taped together so that mechanically they have the appearance of one coil.

A schematic diagram of the arrangement of main field coils is shown in Fig. 4. On the full field position which occurs on all but the last controller notch in series, and in parallel, the two field coils "A" and "B" are connected in series, which, due to the increased field strength, gives a high tractive effort at the wheel rim at a reduced current and speed. On the short field, position, which occurs on the last notch in series and parallel, respectively, coil "B" is cut out and remains open circuited, leaving coil "A" or the short field (weak field) section in the circuit for normal operation. This connection gives a higher speed at increased current. These two conditions are best illustrated by referring to the field control motor characteristic, shown in Fig. 5.

The two sets of speed tractive effort curves can be taken to represent, respectively, the characteristic of two non-field control motors of different speeds but same horsepower rating. The slow speed high tractive effort motor is the most economical in accelerating, while the higher speed motor permits maintaining a higher schedule speed. Thus the two good features of both non-field control motors are embodied in one with field control.

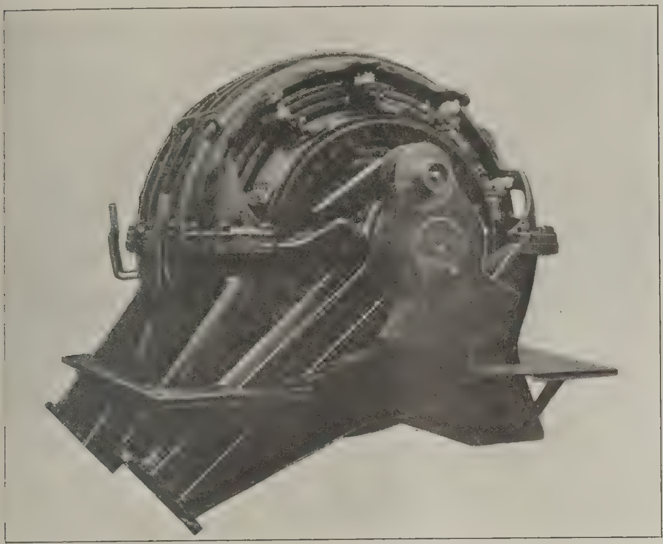

Fig. 3—Pennsylvania 2,000 H. P. Field Control Locomotive Motor.

In the old motors without commutating poles it was necessary to employ a larger number of field turns in order to secure a strong field to get satisfactory commutation. With commutating poles and present day motor design, it is possible to employ a much weaker field than formerly and still obtain satisfactory commutation and freedom from flashing. With the modern non-field control motor the field strength and hence speed and tractive effort is a compromise between those of full field and short field of the field control motor, using the same frame.

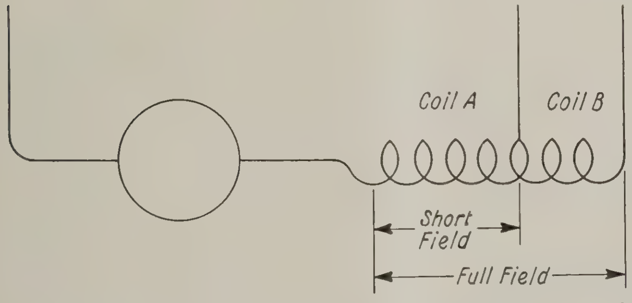

Fig. 4—Schematic Diagram Showing Principle of Field Control.

The most prominent factor which determines motor size for a given service and car weight is that of continuous or root mean square current capacity. With a slow speed field control motor, the heating current for average city service is approximately 10 per cent less than that for a slow speed non-field control motor. It is usually the case that for a service where a non-field control motor has just enough capacity for a given service, a field control motor one size smaller will do the work satisfactorily. Thus an additional saving in weight and energy consumption is realized.

Many operating companies face the problem of limited power station capacity as well as the requirement of more cars. The field control motor by reason of its lower energy consumption and continuous current reduces the demand on the power station, hence a possible saving in powerhouse investment in providing for additional equipment. Furthermore, by the retirement of obsolete cars, and in all probability heavy weight cars, approximately 10 per cent more new cars, equipped with field control, can be operated from the power station capacity released by the retirement of old cars, than if non-field control were used.

Field Control in Interurban Service

Interurban service presents various conditions which must be met, with the same motor equipment. Practically all interurban railways enter one or more large towns or cities over tracks several miles in length. This condition generally requires slow speed running and a relatively large number of stops, and, therefore, this part of the service is most economically maintained by a slow speed equipment. Many of these railways give both local and limited service. It is, of course, desirable to use the same motor and gear ratio for both classes of service. With the same gearing, the local service because of more frequent stops will work the motors more nearly up to their full capacity than will the limited service. The limited service is most often considerably less than one-half of the total service. It is here that field control produces economical running over the slow speed city sections, permits the use of a gear ratio which is economical for local service, and with the same gearing gives a higher limited speed than could be obtained with the same size non-field control motor, correctly geared for the local schedule. This tends not only towards economy in local service, but also towards reducing the motor capacity required for the operation of frequent stop local service, and high speed limited service with the same gear ratio.

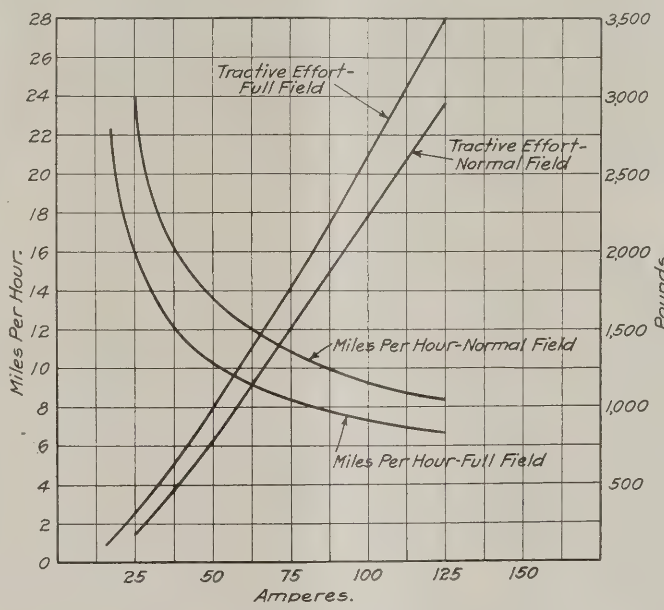

Fig. 5—Field Control Motor Characteristics

For high speed service it is advantageous to use a motor having a high R.P.M. The armature speed is determined largely by the balancing speed required to maintain the schedule. In this way a relatively light motor will perform the high speed schedule for the reason that increasing the armature speed increases the horsepower rating of the motor, as well as the ability of the motor to perform the increased work. A limiting factor to high speed armatures is that of mechanical strength with high peripheral speed. With an abnormally high speed armature it may be necessary to use a large gear reduction. In such cases the speeds on descending grades could easily exceed the mechanical strength of the armatures, banding, etc.

A 75 h. p. field control motor geared for local service, as heretofore described, and operating as shown in the speed time curve, Fig. 6, will maintain a limited schedule speed of 38.4 miles per hour, which is the same as that possible with the next size larger non-field control motor, At the same time, the 75 h. p. field control equipment, as compared to the standard 90 h. p. equipment, reduces the energy consumption 15.9 per cent for local service and 11.7 per cent for limited service. The energy consumption in limited service is somewhat more than with the ordinary 75 h. p. motors on account of the faster schedule speed maintained with the field control motor. The comparative results are shown in table 2.

Table II.

Motor type	Standard	Field control	Standard	Standard	Field control	Standard
Length of run, miles..	1	1	1	6	6	6
Time of run, seconds..	150	150	150	611.8	563	563
Length of stop, seconds	12.5	12.5	12.5	60	60	60
Schedule speed, m.p.h.	24	24	24	35.3	38.4	38.4
Accelerating rate, m.p.h.p.s.	1.25	1.25	1.25	1.25	1.25	1.25
Braking rate, m.p.h.p.s.	1.25	1.25	1.25	1.25	1.25	1.25
Motor equipment	4-75 hp.	4-75 hp.	4-90 hp.	4-75 hp.	4-75 hp.	4-90 hp.
Amperes at full load of motor	130	130	156	130	130	156
Car weight, equipped and loaded, tons....	38	38	39.5	38	38	39.5
Accelerating current, amperes per motor..	127	122	177.5	127	122	177.5
Speed at which rheostats are all out, m.p.h.	21.3	20.3	28.2	21.3	20.3	28.2
Coasting time, seconds.	60	70	77.5	67.8	86.2	86.7
Speed at which brakes are applied	27.1	26	25.7	30	30	30
Kw.-hr. per car-mile..	2.4	2.27	2.70	2.025	2.11	2.39
Watt-hr. per ton-mile.	63.2	59.7	68.4	53.4	55.5	60.5
Temp. rise in service from air 25 deg. C.	58	60	70	50	58	60

It will be noted that the fourth column labeled "standard" will not maintain the necessary schedule in the limited service. It will require four 90 h. p. motors as tabulated in the sixth column to maintain a schedule speed equivalent to that which is possible with the field control equipment as shown in the fifth column.

The sub-station capacities for interurban systems are usually determined by the maximum loads they are called upon to carry and the commercial apparatus available. With single track lines, the peaks will usually occur at passing points, where two cars or trains are starting. With the field control equipments, these peaks are reduced from 10 to 20 per cent throughout the greater part of the acceleration. Reference to the speed time curve shown indicates that for a short period at the end of the acceleration a relatively high peak is attained. This peak can be reduced by the motorman holding on the full field notch for a slightly longer time than on the other notches before going over to short field. As a matter of fact it seems to be a habit of the motorman to hold on next to the last notch on full parallel for somewhat longer time than on the other notches. This is especially true for city service. It would then appear that these peaks are frequently reduced as a consequence of the method of operation of the controller by the motormen.

On many interurban roads there are severe grades. With a field control equipment these grades can be taken at reduced current either in series or parallel. In some cases it may be advisable to use the full field notch in parallel even though the current is somewhat more than with non-field control equipment operating in series. The former would save time and reduce motor heating.

To perform a given service, a smaller size control motor will usually do the same work as the next larger size non-field control motor with both properly applied.

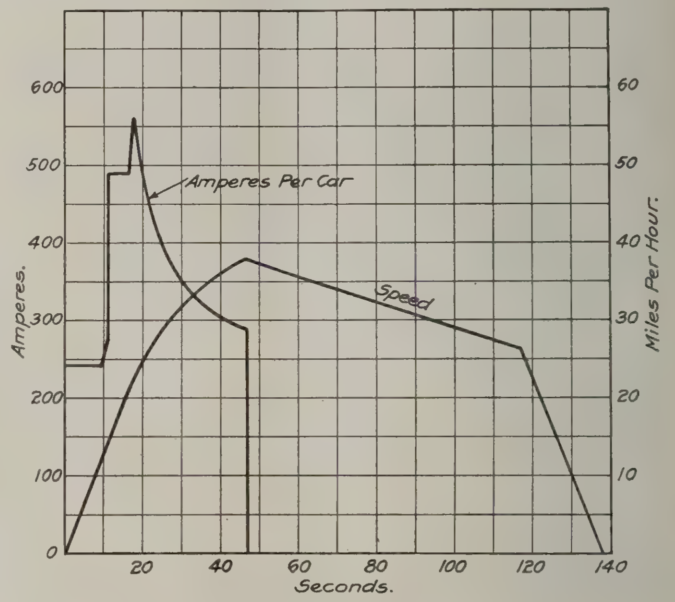

Fig. 6—Speed-Time Curve for Interurban Car Equipped with Field Control Motors.

Conclusion

The prime object of field control is that of enabling railway companies adopting its use to operate more efficiently.

Although a field control equipment is somewhat more expensive in first cost than one without field control, it may be "penny wise, pound foolish" policy to purchase the non-field control equipment. It has been found in many cases that field control equipments pay for the added first cost in from two to three years. Hence the saving after this period is so much "velvet."

Field control has in recent years been applied to all classes of railway service and the indications are that it will be applied to far greater extent in the future.

To date the application of field control motors in this country amounts to approximately 840,000 h. p., distributed among some 50 operating companies.

It is difficult to determine the total annual saving effected by its use. It is, however, estimated at approximately one-third of a million dollars per year.

Six Months' Tungsten Production.—The tungsten production of the United States during the first six months of 1916 exceeded the production of this or any other country in any previous 12 months. Prices reached more than 10 times their ordinary level, largely because of the need for high-speed steel. The output was equivalent to about 3,290 short tons of concentrates valued at $9,113,000.

Design, Maintenance and Operation of Electric Rolling Stock[*]

IT has been considered best not to include in the report descriptions of foreign practice, not only because these methods are largely experimental as yet, without accepting standards, but as well because the foreign locomotives are of comparatively small power.

In the design usually used on electric surface cars and as applied to the Detroit River Tunnel engines, approximately half the weight of the motors is carried on the truck transom and the balance on the axle of the driver, the power of the motor being transmitted through single reduction pinions and gears. On trolley cars there is generally a pinion on but one end of the motor shaft. With motors exceeding 250 to 300 hp. there is usually a pinion on both ends of the motor shaft, driving corresponding gears fastened to the driving axle. This is the case with the Detroit River Tunnel electric locomotives. There is a motor for each pair of drivers, and about half its weight is carried by springs.

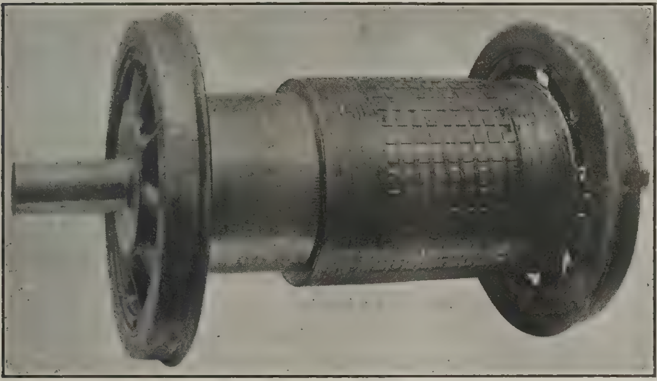

Fig. 1. New York Central Gearless Motor.

The first New York Central electric locomotives had a four-wheeled guiding truck at each end. The drivers are in the central group of four, of larger diameter than the wheels in the guiding truck; the armature is mounted directly on the driving axle. There is sufficient clearance between the armature and pole pieces to allow dropping the drivers as easily as those of a steam locomotive which has had the main and side rods removed. The armatures of these motors are not spring-supported. There is a motor for each pair of drivers. This has led to the opinion they would be hard on the track. The fact is there has been no track distortion or undue wear of the rail.

Fig. 1 shows one of the gearless motors by itself. All of the New York Central electric locomotives are equipped with similar gearless motors.

Figs. 2 and 3 give a general idea of a spring, or flexible gear, for transmitting the torque of the motor to the driver, used on single-phase commutator motors to soften the alternating impulses of the motor, and have been applied to the Chicago, Milwaukee & St. Paul direct-current electric locomotives recently built, resulting in an exceedingly quiet-running machine. The spring gear has been in service too short a time to warrant final conclusions being drawn, but in all probability these will be favorable. The Milwaukee passenger engines run successfully at 60 m. p. h.

In the running gear of the Pennsylvania electric passenger locomotives the motor is mounted on the main frame and transmits its power through main rods to a jack shaft, and this in turn to side rods. The driving mechanism, except the side rods, is spring-supported. There are no gears. Each motor drives two pairs of drivers.

Fig. 4 shows how the pull of the Norfolk & Western motors, which have a pinion on each end of the armature shaft, is transmitted through a jack shaft to side rods, and through these to the drivers. As in the case of the Pennsylvania engines, the driving mechanism is cushioned by springs, except the side rods. There is a motor for each pair of drivers. In service the pinions and gears are covered by a gear case.

Fig. 5 shows a more recent type of quill drive, used on New Haven electric passenger, freight and switching engines, all of which are geared. In this design the torque of the motor is transmitted to the drivers through curved arms attached to the quill, the outer end of these arms compressing coiled hour-glass springs which are seated on the driving-wheel center. In this design the entire motor is spring-supported.

Summary.—Experience with electric locomotives has not been sufficient to warrant a final conclusion as to the merits of the various systems of transmission of power from motors to drivers. The fact that scarcely two orders for electric locomotives have been built from in view of the infancy of electric traction as applied to the same plans is good proof of the above statement and, steam railways, it will not be surprising if a variety of designs will continue to appear.

It is interesting to note that the Scotch yoke, which has been used rather frequently on foreign electric locomotives, has not been applied in America.

Considering only the means of transmitting power from the motor to the drivers, including cost of repairs and losses by friction, the designs without gears or transmission rods are the most efficient for train speeds exceeding 45 or 50 m. p. h. Below these speeds the gear and pinion are probably the most efficient.

The jack shaft has so far been found not entirely satisfactory, as it appreciably increases internal friction and it has been found difficult to keep it from pounding and running hot. The quill springs have given rather more trouble than is desirable by breaking or becoming unseated. Where gears are used, some design of spring or flexible gear will probably be found desirable for steam railroad electrification.

Delay Statistics

An inquiry directed to seven steam railways using main line electric traction disclosed the fact that, though they all kept statistics of train delays due to defects of their electric equipment, no two compiled them on the same basis. On some roads a train delay is included in the reports when it amounts to one minute and only when it amounts to ten minutes on others. Some reports separate man failures; others do not.

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[*] Report of the Master Mechanics' Committee, of which C. H. Quereau, superintendent electrical equipment, New York Central, is chairman. Presented at the Atlantic City Convention.

Under these conditions it is evident that, while the present reports may serve local needs admirably, there can be no fair or useful conclusions drawn by a comparison of the delay statistics of any two of these roads. Because of these wide variations, it seems certain the different roads cannot have the same ends in view or have not given the matter the consideration it deserves.

It is probable in a number of cases the delay statistics are compiled by the operating department from a departmental standpoint without considering the needs of the motive-power department.

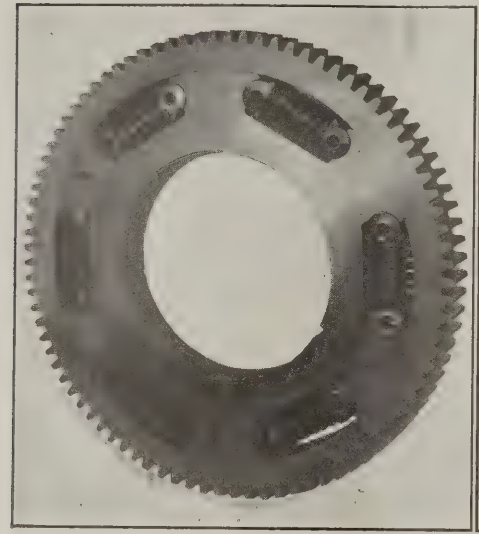


Fig. 2. Flexible Gear Assembled.

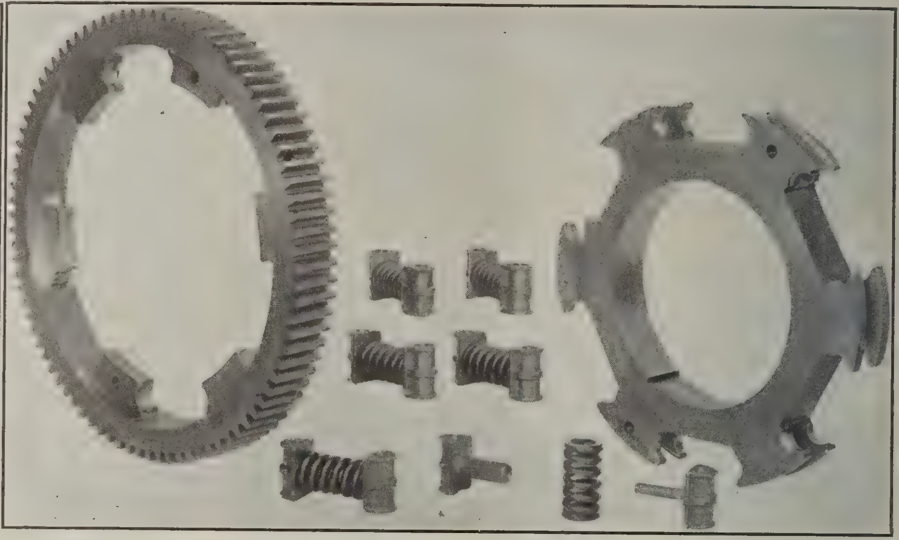


Fig. 3. Flexible Gear Parts.

What object should be sought by the motive-power department in preparing the statistics showing train delays due to failure of equipment and enginemen? We believe it should be to so compile them as to form a basis for judging the efficiency of the equipment itself and of the organization maintaining and running it. The statistics should show separately the delays caused by the mechanical parts, such as brake shoes, couplers and air brakes; the electrical parts, such as motors, contactors and resistance, and delays due to man failures, such as improper proportion of motor and trailer cars, tight brake connections or a circuit breaker not closed by the motorman, and the minimum delay to be included in the records should be low enough to uncover defective equipment and handling.

As a general proposition, the delay statistics should inform the superintendent of electric equipment of every train delay due to the failure of the equipment and the carelessness or ignorance of those operating it. The workable minimum time for a delay should be not more than one minute. A responsible official cannot afford to fool himself by recording only such delays as are greater.

It is the opinion of the committee that trailer-car mileage should be included with motor-car mileage for all multiple-unit car statistics. It is quite evident that a motor car is combination with two trailers is required to do more work than a train of three cars, each of which is a motor car. Including the trailer car mileage gives a fairer measure of the work done. As both classes of the cars are maintained by the same men and the mechanical features are identical, it is impossible to accurately separate the cost of maintenance between them.

In the report of this committee, presented at the 1914 meeting, the use of the unit Miles per Detention rather than Miles per Minute Detention as a basis for delay statistics was recommended. The committee renews that recommendation.

Summary.—There is practically no uniformity in the delay records of railroads at present.

There should be delay statistics, compiled with special reference to the needs of the motive-power department, separate from the division superintendent's.

The motive-power department statistics should show Miles per Detention for the guidance of the motive-power department and Miles per Minute Detention for the use of the division superintendent.

The records should show train detentions under the headings: Man Failure, Mechanical Failure, Electrical Failure.

All train detentions of one minute or more should be recorded.

Delay to following trains should not be included in the motive-power statistics. Such records are confusing and misleading, hence more than useless.

Discussion

Mr. Quereau: There are seven members on this committee, each of whom is connected with a railroad which has been electrified to a greater or less extent. No two of these roads have the same system, the same equipment, and that will account for the fact that there is no more definite information in the report than that which is given.

The New York Central is using on its electric locomotives what is known as the bi-polar gearless motor. The motor is mounted directly on the axle of the driver, and the drivers can be dropped exactly as from the steam locomotive after the side and main rods have been removed. That motor is considered dangerous by some people. What I have to say of this motor will apply to the conditions on the New York Central Lines, and other trunk lines using a 100-lb. rail, with a good track. What the results would be on a lighter track would be a matter of opinion. It is entirely safe under the conditions under which it is operated on the New York Central. It is true that the locomotives develop a tendency to what, in steam practice, is known as nosing. When a certain amount of lateral motion is accumulated, no matter where it may be, in the center, in the plates, or in the hub, there is a tendency to nosing. I believe you will agree with me that the trackman would be the first to criticise any device which did any damage to his track. It is the universal consensus of opinion among the trackmen on the New York Central, in the territory in which these locomotives operate, that there has been no single case of deformation, distortion or damage to the track from these motors. I believe that evidence should pass without question. There is no difficulty in keeping the lateral motion in such condition that the engine rides beautifully. I have ridden on most of the designs of electric locomotives, and none of them ride as smoothly and quietly, under the conditions I specify as to track, as the bi-polar gearless motor. The lateral motion allowed is about three-quarters of what would be considered the limit for steam operation. The maintenance of these motors is very low. Previous to my connection with the maintenance of electrical equipment, my experience was entirely in the line of steam railway maintenance. When I undertook the work in which I am now engaged I had great fear of the gears. My idea was that it would wear out, break and make all sorts of trouble. That fear has entirely disappeared. We have gears which have made 200,000 miles on 200-hp. motors. With the modern heat-treated steel I think we may reasonably expect 300,000 miles at 30,000 miles a year. We can forget the gears and pinions and simply watch them once in a few years.

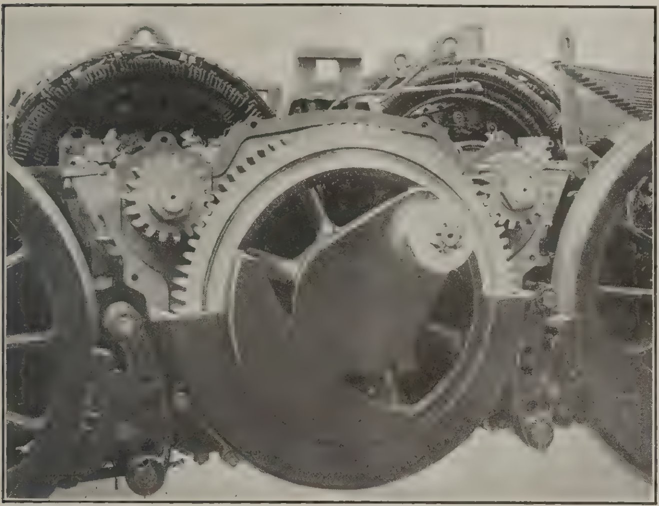


Fig. 4. Transmission Gears of the Norfolk & Western Electric Locomotives.

In connection with the matter of drive for electric locomotives, there is a very interesting article in the *Electric Railway Journal* of June 10, by Mr. Shepard, which I have no doubt you will be interested in reading.

Frank Rusch (C., M. & St. P.): I am not in a position to talk very much about the electrification of our road. But, as far as I am informed about it, the operation has been a success, and far beyond our expectations. Possibly if I come to the convention next year I can tell something about operating motors over the Rocky Mountains.

G. W. Wildin (N. Y., N. H. & H.): We have about 16 switching locomotives of the geared type, with a pinion on each end of the armature. There are solid gears on the driver. We find that in this case the flexible gear would be much more satisfactory, due to the fact that when you want to put a new pinion on one end of the shaft and an old pinion on the opposite end, one pinion is doing the major portion of the work until it wears down and the other pinion takes hold. That is in the case of a rigid gear. In the case of a flexible gear you can put on a new pinion with the old one without difficulty.

We have a remarkable record as regards the operation of these 16 switching locomotives. We have gone something like 26 months without detention to the switching service due to failure of the engine. We are contemplating the purchase of 20 or 30 more, with very little change as to size and construction, simply strengthening up a number of parts which we found to be a little weak in design. We have 36 freight locomotives in operation between our Harlem River terminal and New Haven, a distance of about 65 miles. We are hauling 3,000-ton trains with two locomotives operated in multiple. We have about 47 passenger locomotives and are getting between shoppings on these locomotives about 110,000 miles. We are gradually bringing the cost down to compare favorably with steam locomotives. These are of a complicated type, being both alternating current and direct current locomotives. Naturally, we would expect more trouble from a locomotive of this kind than a locomotive of the straight alternating current or straight direct current type. Such trouble as we have comes in changing from one system to the other, especially in the winter. When we pass from the third rail to the overhead system the pantograph is rather sluggish, not being operated on the direct current zone, and in the reverse direction the third rail shoe fails to go down properly, due to the fact that snow and sleet accumulate on it.

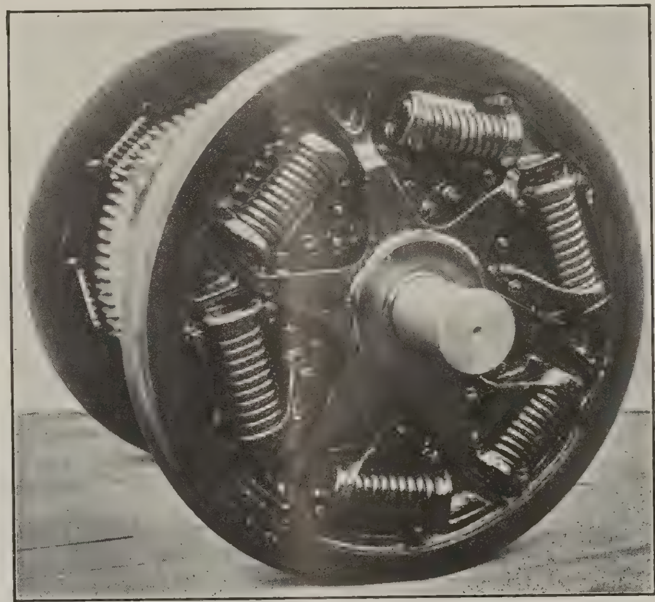


Fig. 5. Latest Quill Drive for the New Haven Electric Locomotives.

Prof. L. S. Randolph: I think it would be a good plan if the committee could formulate some system by which there could be some uniformity in the reports in regard to the detentions and failures.

Mr. Quereau: I want to impress on the gentlemen here that the mechanical men in charge of maintenance of electrical equipment are in a new field, not particularly in the electrical end of it, but in the mechanical end. Electrical engineers, six or eight years ago, were cocksure, each school by itself, as to what was coming. Now they do not know so much about it. Mechanical men knew a lot about locomotive matters, as to what ought to be. They do not know so much as they did, because experience has shown that we cannot apply directly to the electrical locomotive all the experience we gained in the steam locomotive.

(The committee was continued.)

Midi Railway Electrification in France

In preparation for the reconstructive period which is bound to come after peace has been declared in Europe, the Midi Railway, which operates electrified lines in Southern France and to the frontier of Spain, is having eight single-phase electric locomotives built, each designed for both freight and passenger service. The new locomotives are intended for use on the system's Western group of lines and will ultimately be placed in service on the main line from Toulouse and Bayonne.

One of the Midi High Speed Electric Locomotives.

Each locomotive will have a continuous rating of 1,500 h. p. and a one-hour rating of 1,800 h. p., at a maximum speed of 62 miles per hour. There will be six motors of the double fed type on each locomotive. The motors will be mounted in pairs, each pair being geared to a quill surrounding one of the driving axles and connected to the drivers by helical springs. Clearance is provided between quill and axles so that the vertical movement of the drivers will be independent of the motors, the design being similar to that employed on many American locomotives.

The 48 motors for these locomotives are being built in this country at the East Pittsburgh plant of the Westinghouse Electric & Mfg. Company, due to the crowded condition of work at the Havre shops of the French Westinghouse Company, with which the order for the locomotives was placed. Under ordinary conditions the entire equipment would have to be made in France, but as a result of existing war conditions the manufacturers were given permission by the French government to have the material for the locomotives made wherever it was most convenient. The motors are of 300 h. p. capacity at 790 r. p. m., with 312-volt, 16 2-3-cycle single phase alternating current.

The employment of single-phase locomotives for this project is the result of an interesting process of development, single-phase power having been used on the Midi Railway since 1908, at which time 10 miles of track near the Mediterranean coast were electrified. In 1910 the electrification of 175 miles of single track was authorized. Seventy miles of track was on the main line and 105 miles on intermediate branches. Bids for electric locomotives were requested and those of six companies accepted. The locomotives furnished were subjected to tests during 1911 and 1912. As a result of these tests, which were made on a 15-mile section of the line, three of the locomotives, including the one furnished by the French Westinghouse Company, were accepted.

One of the major reasons for this extensive electrification was the availability of large amounts of hydro-electric power. The Eastern group of lines is furnished with power from several stations, two on the Tet River, one at Fontpedrouze, another at Porte in the Valley of the Caroe—the two latter for stand-by service—and a sub-station at Villefranche. Power for the Western group of lines is supplied by a hydroelectric station at Soulon. Two other stations are projected; one at Eget, on the Aure River, and the other at Orleans. These will supply power to the line from Dedous to Aronanos.

The Thompson Electric Company

The Thompson Electric Company, 5606 Euclid avenue, Cleveland, Ohio, has been awarded a silver medal by the Third National Exposition of Safety and Sanitation, New York City, May, 1916, in recognition of work done in the promotion of safety through their campaign for clean lamps and the development of their Safety cut-out hanger, or automatic disconnecting lowering device, which is being used extensively by industrial plants and railroads.

The device is designed especially for use on large Mazda and Type C or nitrogen lamps, the object being to keep the lamp-cleaners on the ground, in a position of safety, and to make it so easy and safe to get at the lamps for cleaning, that there will be no excuse for losing the benefit of a large percentage of the light which they are producing or which they are capable of producing.

Insulation of Electrical Machinery

By Gordon Fox

THE three elements of an electrical machine are copper, iron and insulation. Copper and iron are active elements, while insulation is inert, but none the less important. The primary function of insulation is the electrical separation of conductors from each other and from the frame. Aside from this, insulation must be able to withstand mechanical stresses and to conduct heat away from interior points to surfaces where ventilation is possible. Unfortunately, poor electrical conductors are usually poor heat conductors, so that rapid transfer of heat is a problem without easy solution. Neither the iron nor the copper in a machine are seriously affected by temperatures such as are attained in electrical apparatus, nor are they greatly damaged by water, oil or dirt. Insulation is affected by all these things. Being thus the weakest link in respect to reliability, its importance cannot be overestimated.

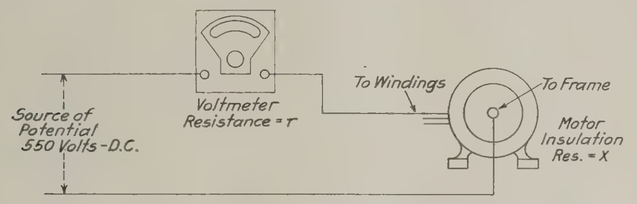


Fig. 1. Diagram of Connection for Measuring the Resistance of a Motor.

Ohmic Resistance and Dielectric Strength

Insulation enables a conductor to have a definite potential and enables adjacent conductors to have differing potentials. Because of the different potentials, current tends to leak slowly through the insulation by paths offering even the slightest conductance. The ability to prevent this leakage may be termed ohmic resistance. If two conductors of different potential be placed adjacent to each other, but separated from one another, there is always a strain in the intervening space due to a tendency for the medium in that space to break down and allow current to arc across from one conductor to the other. The ability to prevent such disruptive discharge is called the dielectric strength of an insulator. The difference between ohmic resistance and dielectric strength may be most readily seen if we consider a few simple examples. Suppose our two conductors of differing potential are separated merely by intervening air. Air is an excellent non-conductor, having extremely high ohmic resistance, but it breaks down easily and an arc is set up across it quite readily. Suppose now that we insert a sheet of paper between the two conductors. Paper has lower resistance than air, so that the total ohmic resistance is decreased, but paper has much less tendency to break down and permit disruptive discharge, hence the dielectric strength is increased. Next let us replace the paper with a sheet of composition mica. The resistance of the mica plate is less than that of paper; in other words, it is a better conductor, so that the ohmic resistance is still lower than before. Mica, however, is comparatively impervious to disruptive discharge and the dielectric strength is now very high.

It has been determined that leakage through insulation is in reality flow of current across bridges or films of minute conducting particles. It follows that insulation which is wet or dirty has a lower resistance than that which is dry or clean. A machine may have low insulation resistance and, after being thoroughly cleaned and dried, it may show several times as high resistance. Ohmic resistance is thus not an accurate indication of the character of insulating material. It is, rather, an indication of its condition. It is evident that insulation in poor condition is more likely to break down than that in good condition. Low resistance, therefore, usually indicates comparatively low dielectric strength for the insulation involved. As was previously shown, this is not true in the reverse sense, as insulation may have low dielectric strength and high ohmic resistance simultaneously. Material which is very dry, for instance, usually exhibits high resistance, but may be full of cracks and crevices filled with air across which current will not leak, but may readily arc.

Determination of Ohmic Resistance

The exact ohmic resistance of insulation can be determined only by use of a galvanometer, but, since this resistance is more or less variable, depending upon humidity and cleanliness, it is not necessary that exact values be found. The resistance can be determined with sufficient accuracy by the use of a direct current voltmeter. The voltmeter is connected in series with the unknown resistance and across a source of constant direct current potential. The connection for measuring the resistance of a motor is shown in Fig. 1. The insulation resistance X is to the resistance of the voltmeter r as the volts drop in X is to the drop across the voltmeter r. Suppose our source of potential is 550 volts and the meter reads 6 volts. Suppose further that the voltmeter resistance (stated on cover of case) is 15,000 ohms.

$$X : 15000 :: 544 : 6$$
$$X = 1{,}560{,}000 \text{ ohms.}$$
$$= 1.56 \text{ megohms.}$$

The insulation of low potential machines should range from .05 megohm to 1 megohm, the lower value applying to large machines of very low voltage, as, for instance, a 1,000 kw. 110 volt generator. The higher value would apply to a 100kw. 1,000 volt machine. Of course, if the resistance exceeds this value all is well. The A. I. E. E. requirement for insulation resistance is given in the formula

$$\text{Megohm res} = \frac{\text{Rated voltage}}{\text{KVA capacity} + 1000}$$

Since insulation resistance varies according to the voltage applied it is desirable that a test voltage of 500 volts be used where possible in order to secure comparable results. A machine will indicate lower resistance with a higher test voltage and vice versa.

Test for Dielectric Strength

Dielectric strength of insulation is more important than the resistance. This factor is tried by applying a high alternating test voltage between each electric circuit and the other electric circuits and from each electric circuit to ground. A 60-cycle sine wave voltage is specified by the A. I. E. E. The value of the test voltage depends upon the size of the machine, the rated voltage and the service. Most machines are tested by application, for 60 seconds, of a test voltage of twice the rating plus 1,000 volts. Thus, a 1,200-volt machine would be tested at 3,400 volts (4,800 volts crest of wave) and a 12,000-volt machine would be tested at 25,000 volts (35,400 crest). The few exceptions to this rule are found in the A. I. E. E. standardization rules, articles 500 to 512.

It might be noted that the above tests, if successfully passed, insure a factor of safety for the insulation between separate windings and between the windings and frame. They do not, however, furnish a test between adjacent coils of the same winding having different potentials, nor do they test the individual turns of insulated joints. A generator, for instance, could not be tried for breakdown between phases of coils unless all the individual coils were disconnected from each other. In order to make such a test and assure a factor of safety in this respect it is suggested that the equipment be required to withstand a 25 per cent to 50 per cent overvoltage for a short period. Transformers are regularly subjected to a 100 per cent overvoltage run, but the method has never been commonly extended to apply to motors and generators. The practice is recommended by a few and its further use seems warranted.

Insulating Materials

Among the common materials entering into the insulation of electrical machines are: cotton, silk, paper, fullerboard, fiber, rubber, gums, and resins, mica and asbestos. In general, the same kinds of insulating material are used both for low voltage and for high voltage machines, the insulation being made heavier the greater the voltage to be withstood. In low voltage motors and generators the function is largely one of mechanical separation and insertion of ohmic resistance since the volt-withstanding ability is not severely tried. High pressure machines, say above 6,600 volts, have their insulation proportioned more particularly with reference to its ability to withstand high tension. The amount of insulation required increases more rapidly than does the voltage, since disruptive strength does not increase proportionately with the thickness. The rate of growth of dielectric strength with thickness of insulation is not a definite, accurate ratio, but varies with different materials and different conditions of the same material. Generally speaking, doubling the thickness increases the dielectric strength about two-thirds.

All of the materials mentioned above, except mica and asbestos, are deteriorated by moderate heat. Cotton and silk are used largely because of their flexibility. Both are highly porous and absorbent and are intended essentially as mechanical separators, the interstices to be filled with varnish. Cotton insulation can be likened to lath or expanded metal and the varnish is comparable to the plaster or cement applied thereon. The varnish is most frequently applied after the tape is in place, although empire cloth and friction tape are types of preliminary filled insulation. Silk is, of course, much finer in texture than cotton, though more expensive. It is used where the space for insulation must be minimized. Silk is excellent for some repair work, since it affords better protection with less bulk than cotton. For instance, an abrasion on the portion of a formed coil which must be replaced in a slot can advantageously be taped up with silk, which affords a safe covering without bulging the coil. Paper is a comparatively good insulator; any close grained grade, called fish paper, is commonly used. It is not flexible, but is effectively used for straight runs such as cells for slots into which the coils are inserted. Paper also is often treated with varnishes, more frequently before insertion. Fiber is in reality paper stock formed into plates and tubes. It is used extensively for washers and bushings, but absorbs moisture readily. Rubber is not much used internally in electrical machines as it deteriorates under moderate heats. Moulded insulations are used to some extent for accessories. Mica has high dielectric strength and is not deteriorated by such low heats, but it is inflexible and weak mechanically. It is prepared for use by forming ribbons or plates composed of mica flakes cemented to a thin, tough paper, supporting medium by special binding gums. The most familiar use of mica is as micanite or micabond for commutator segment separation. Mica ribbon is quite commonly used for coil insulation where high temperatures are to be experienced. Large, high speed turbo generators in which high temperatures are necessary because of large outputs from small bulk and enclosed motors for railway, haulage and mill service are types utilizing mica insulated coils. Asbestos is a poor insulator in itself. It is porous, has comparatively low resistance, is bulky and weak mechanically. It is, however, largely unaffected by heat. Resins and gums serve a manifold purpose. They act as fillers to close all pores and spaces as with cotton insulation. In this way they form the real insulator, the cotton merely being the support. They also serve to conduct heat and to cushion against mechanical stresses. Moreover, by softening when heated, they tend to prevent the insulation from becoming dry and brittle at high temperatures. Varnishes are used to prevent water from entering and form-

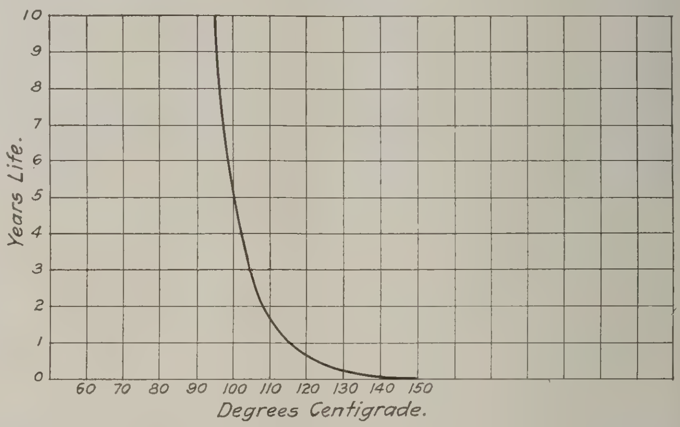


Fig. 2. A Curve Which Shows How the Life of the Ordinary Fibrous Insulating Materials Varies with the Operating Temperature.

ing leakage paths. To do this they must either keep out the water entirely by closing all pores externally or they must form a solid impervious coating of the body of the varnish on the conductor itself inside the insulation. Brush application of varnish serves to coat the exterior and prevent entrance of moisture. Vacuum treatment endeavors to work the varnish in next to the conductor, forming a non-conducting layer and filling the pores as far as possible. Varnish reduces the extent to which moisture is absorbed, but it is unable to stop absorption altogether. Material which may in liquid state fill the pores completely will fail to do so after drying by evaporation. Insufficient elasticity of the varnish is a fundamental defect, as it is unable to follow the expansions and contractions of the conductors sufficiently. Its continuity is therefore broken up and small crevices occur into which moisture can enter.

Mechanical Stresses

The second important requirement of insulation is the ability to withstand mechanical stress. The conductors in a machine exert forces the magnitude of which are not often fully comprehended. Field coils tend to travel lengthwise along the pole pieces, while armature, stator and rotor conductors exert a pressure on the sides of their slots. The insulation must cushion the conductor, preventing vibration as far as possible. There is nearly always some vibration in such parts as armature coils. High speed machines and those suddenly reversed, stopped and started, are particularly subject to this condition. In railway motors mechanical vibration is ever present to cause deterioration of any insulation which is already brittle or which later becomes so, due to heat or long use. Movement of conductors must be restricted to a minimum by banding, wedging and bracing. Vibration causes cracking of the insulating filler or varnish. This destroys its continuity and paves the way for breakdown. An insulating covering which is full of small cracks and crevices has a dielectric strength little greater than air alone, since the opportunity arises for disruptive discharge across the air-filled breaks. Continuity of the surface is also important in preventing the absorption of moisture and dirt. After the exterior becomes cracked the insulation resistance is likely to be reduced.

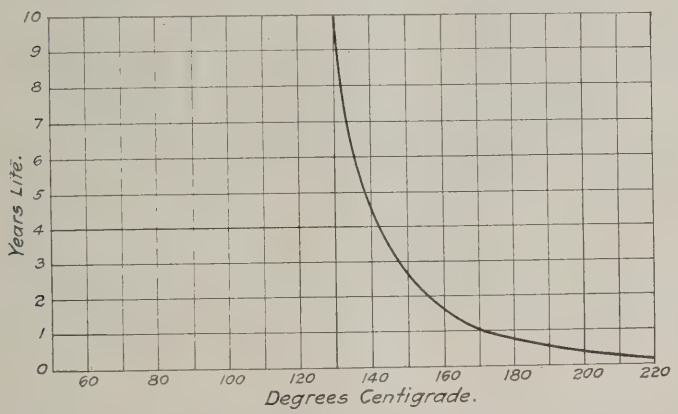


Fig. 3. A Curve Showing the Life of Heat Resisting Insulation at Various Temperatures.

Heat Resisting Qualities

The third essential of good insulation is its ability to undergo fairly high temperatures without excessive deterioration. Insulation is the limiting consideration in rating a piece of electrical apparatus. The insulating materials most commonly used for motors and generators will withstand a continuous temperature of 100 degrees Centigrade and afford comparatively long life. The life of an insulation not mistreated or subjected to undue moisture, oil or dirt, depends largely upon its temperature when in operation. A curve which shows how the life of the ordinary fibrous insulating materials varies according to the operating temperature is shown in Fig. 2. This curve gives, of course, merely a general relation, it being an average for many specific materials. It is found that intermittent loading and steady loads have about the same influence on insulation life, provided that the peaks are not of such long duration that the machine becomes heated to a temperature corresponding to the extreme load. The temperature attained by an intermittently loaded machine is the same as that reached by the machine operating continuously for short periods. It is for this reason that haulage motors, elevator motors and such types are said to have 30, 40 or 60 minute ratings. This expression means that the machine, carrying full rated load for 30, 40 or 60 minutes, will reach the same temperature as will be reached when it is placed in its regular intermittent duty. These ratings are entirely empirical, based upon experience. Some machines are inherently liable to high temperatures. The material in a large turbine generator, for instance, is worked hard and the losses, appearing as heat, are confined in a small frame with comparatively little radiating surface. Totally enclosed railway, mill and crane motors also naturally tend to run warmer than their open prototypes which offer better ventilating possibilities. Either the iron and copper of such machines must be worked to only a moderate degree or else insulation must be used which will withstand higher temperatures without sacrifice of longevity. From the cost viewpoint the latter practice is preferable. Consequently insulations have been developed to successfully stand temperatures up to 125 and 140 degrees Centigrade. Figure 3 is a curve showing the life of this type of insulation at various temperatures. It is similar to figure 2 in that it represents average conditions. These insulations use mica prepared in various ways, but in nearly every case it is cemented to a paper binder as a supporting medium. This supporting material may deteriorate with heat without lessening the insulating qualities of the mica. The material is not strong and must be carefully braced to avoid vibration. Removal of coils for repairs, on which this insulation is used, is also attended with greater difficulties than where cotton tapes are used.

Temperature Limits

It has been stated that fibrous insulations will withstand a temperature of 100 degrees Centigrade and mica insulations a temperature of 125 degrees. This means maximum temperatures. The temperature of the exterior of a coil may be 10 to 15 degrees cooler than some internal hot spot. Consequently, when temperatures are measured by thermometer it is necessary to make allowance for the difference between internal and external temperatures. When temperature rises are determined by resistance measurements they show the average value throughout the coil and do not indicate the maximum temperature. Consequently, even when this method is used, some margin must be allowed. The difference between maximum internal temperature and surface temperature depends upon the type of machine, kind and amount of insulation and ventilation. Machines of moderately low voltage, having comparatively thin insulation, have a fairly small heat gradient between internal and external points. Ordinary direct current armatures, induction motor primaries, stator and rotor of engine type alternators all have comparatively even heat distribution with plenty of radiating surface and easy ventilation. Large field coils are more difficult to ventilate as are also turbo generator coils and coils of other alternators having long stackings in which the central portions may attain materially higher temperatures than the ends. High voltage machines having thick insulations will have quite steep temperature gradients. It is thus evident that the safe temperature rise allowable above measured values, for a piece of electrical apparatus, depends upon the class of insulation used and the type of machine. A rise which may be perfectly safe for one case may be prohibitive for another. Rises specified for ordinary insulations are 35 to 40 degrees Centigrade above the surrounding air for full load with 50 and 60 degree rises with overloads. For heat resisting insulations rises from 60 to 85 degrees are specified. In apparatus with higher temperatures, requiring special insulation, there is less likelihood of uniform heat distribution and greater margins may be required.

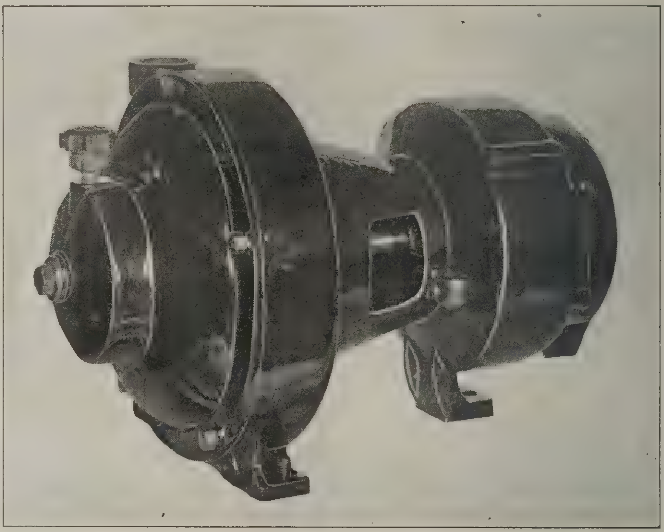
In some classes of apparatus there are certain definite points which are prone to attain higher temperatures than other portions. For example, that part of an armature coil which is embedded in the iron is much more likely to become overheated than are the end connections. The buried portion receives heat both from the copper and the iron while the ends must care for copper losses alone. Also better ventilation is possible for the end portions of the coils. It is therefore advisable to insulate the embedded straight portions of the coils, where little flexibility is required, with mica composite insulation. The ends may then be taped with treated cloth, without fear of injury from the lower temperatures occurring at these points.

As previously suggested, insulating materials are not good heat conductors. For illustration, the heat flow through a copper body is more than 2,000 times as rapid as the flow through tape. Iron is not nearly so good a conductor as copper yet it conducts heat about 400 times more readily than insulation. Air is an exceptionally poor heat conductor and air pockets are therefore extremely undesirable in insulation. It is good practice to make the insulation as thin, compact and dense as possible and to fill the pores with varnish to make it solid. There is a great difference, for instance, between the temperature gradients of a vacuum impregnated coil and one of cotton covered wire externally varnished. Vacuum treatment is applied by first inserting the coil in a vat subjected to about 90 degrees heat and from which the air is exhausted. All moisture is easily vaporized under this condition. Then the gum preparation is pumped into the vat in a hot and fluid condition. It is sucked into the pores and, upon removal, bakes into a very solid unit. Such treatment can, of course, be applied only in original manufacture.

Headlight Generators

A 150-watt, 6-volt, direct-current turbo-generator set is illustrated, which has been developed by the Pyle-National Company, Chicago. It is designed to meet the requirements of the incandescent headlight, both for switching and road service, and differs in several respects from the older types of generator sets manufactured by this company for the arc headlight.

The turbo-generator is small and compact and operates with equal success with either superheated or saturated steam. The turbial is of the constant flow, constant pressure type and no governor valve is used. The speed regulation is controlled by a simple fly-weight centrifugal governor, which forces the turbine rotor out of register with the nozzle. Steam is supplied to the turbine by a ⅜-in. pipe and the exhaust passes out through a 1½-in. pipe.


Pyle-National 150-Watt, 6-Volt Headlight Set.

The generator is of the bi-polar compound wound type. The field frame and poles are made in one piece, entirely enclosing the field windings, which, in turn, are liberally proportioned and well ventilated. The armature is of the ring wound type and, with the commutator, is mounted on a sleeve which can be removed from the shaft by taking out a single screw.

A 2½-kw. generator set has also recently been placed on the market by the same company. This set is designed to supply current both for the locomotive headlight and the coaches in branch line or suburban passenger service. Under the ordinary requirements of such service it will take care of from 7 to 10 cars. It is now being used in suburban service on the Staten Island lines of the Baltimore & Ohio, and one train has recently been equipped by the Chicago & North Western. This set is known as the Type T equipment. It has a governor of the regulating valve type, the valve being controlled by a tension spring fly-weight centrifugal governor mounted on the shaft and attached to the turbine rotor. Steam is supplied by a ¾-in. pipe and a 2-in. pipe takes care of the exhaust. The generator is bi-polar and is wound for 32, 60, 110 or 220 volts.

This set is entirely self-contained and requires no special foundation. Its overall length is 33 in., the height is 19 in. and the width 18 in. It weighs less than 400 lb.

Anti-Friction Bearings in Electric Locomotives

By Arthur V. Farr*

WHEN H. Ward Leonard, years ago, prophesied that railway transportation in mountain regions would be by the electric locomotive method, he hit the truth so accurately that it seems unfortunate that he could not have lived long enough to see the electric system of the Chicago, Milwaukee & St. Paul. If he had been able to see the time of electric railway transportation in the mountainous regions through which this railroad runs, it would have been a great satisfaction to the distinguished inventor.

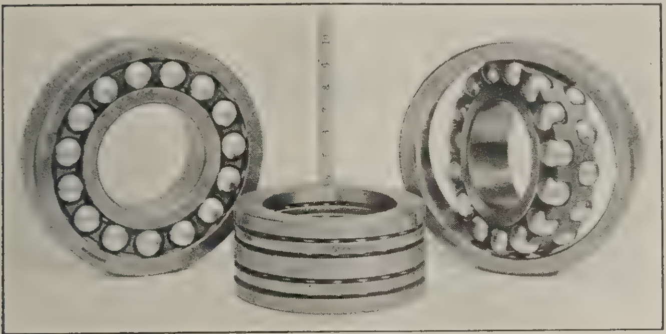


Fig. 1. Views of the Anti-Friction Bearings in the St. Paul Electric Locomotive. The Thrust Bearing Is Shown in the Center While the Radial Bearing Is Shown at the Left with a Deflected View of the Same Bearing at the Right.

One of the interesting features of the equipment installed on the 282-ton electric locomotive now operating on the electrified divisions of the St. Paul, is the motor generator set which provides low voltage current for the control and other auxiliaries. This set consists of a 3,000-volt direct current series motor, having a double winding and two commutators operating in series on 3,000 volts, a small generator for furnishing current for regeneration and for charging storage batteries on passenger cars, and a blower of 13,000 cu. ft. capacity for ventilating the main driving motors. On account of the several functions performed by this set, dependable performance is of vital importance to the operation of the locomotive. Besides furnishing current for control it is also used in connection with regeneration on down grades; for lighting the locomotive interior, and for supplying the low voltage incandescent headlight which takes current from collector rings at one end of the set.

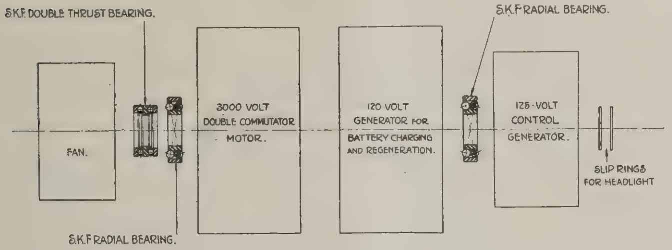

S.K.F. DOUBLE THRUST BEARING.
S.K.F RADIAL BEARING.
FAN.
3000 VOLT DOUBLE COMMUTATOR MOTOR.
120 VOLT GENERATOR FOR BATTERY CHARGING AND REGENERATION.
125-VOLT CONTROL GENERATOR.
SLIP RINGS FOR HEADLIGHT
S.K.F RADIAL BEARING.

Fig. 2. A Sketch Showing the Relative Location of the Various Anti-Friction Bearings in the Set Which Is Installed Longitudinally in the Locomotive Cab.

In order to insure safety, to obtain the highest possible efficiency and to insure reliable operation under extreme weather conditions, these sets are equipped with ball bearings manufactured by the S. K. F. Ball Bearing Company of Hartford, Conn. The bearings are of the self-alining type and consist of an inner race and outer race and a double row of balls made of Swedish crucible steel and a ball retainer of bronze. The inner race contains two grooves, each ground to a radius slightly larger than the radius of the balls, and the inner surface of the outer race is ground in the form of a section of a hollow sphere whose center is at the center of the shaft. It will be seen from a study of this construction that the inner race, together with the balls and retainer, are free to revolve at any angle within the outer race without causing undue strain on the balls. The bearings will thus automatically

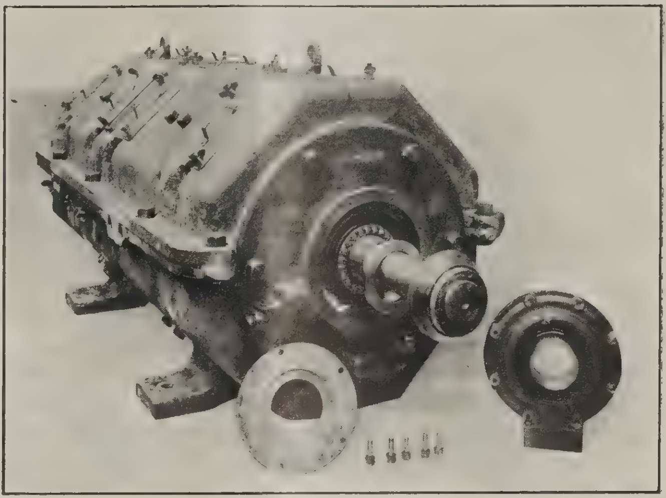


Fig. 3. A General View of the Motor Generator Set With One of the End Caps Removed to Expose the Thrust Bearings.

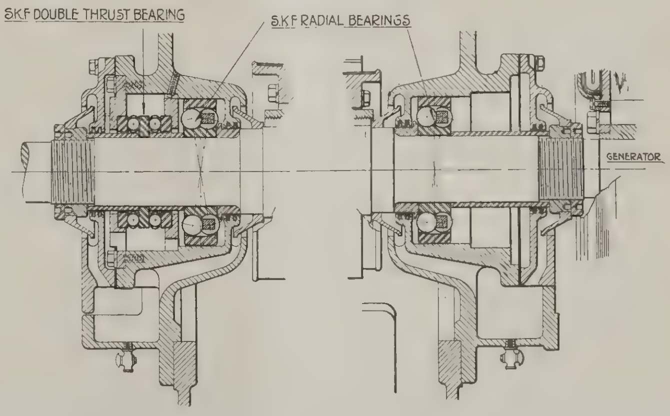


Fig. 4. Detailed Application of the Anti-Friction Bearings in the St. Paul Electric Locomotives.

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*S. K. F. Ball Bearing Company, Hartford, Conn.

and instantly adjust their position to compensate for any shaft deflection or load changes.

The bearings above described are illustrated in Fig. 1, In the center of the photograph is shown the thrust bearing which takes up the shock incident to switching and train handling. This bearing has a capacity of over 5,000 lb. at the normal speed of the set which is approximately 900 revolutions per minute. On the left is one of the radial bearings which is over ten inches in diameter and which has a bore of 4.7 inches. On the right the same type of bearing is shown in a deflected position, which illustrates the arrangement for self-alining used in the construction of these bearings. A complete armature for this set weighs about 4,000 lb., and the dimensions of the air gap around each part of the combined armature are as follows: Motor, about .21 inches; exciter, about .156 inches; control generator, about .125 inches. The location of the bearings in the set, which is installed longitudinally in the locomotive cab, is shown in Fig. 2, and it is seen from the diagram that the set overhangs at both ends. The detailed application of these bearings is shown in Fig. 4, while a general view of the set complete with one of the end caps removed to expose the thrust bearing is shown in Fig. 3.

Forty-two of these locomotives are either in operation or under construction employing a total of eighty-four of these sets. It is planned to have all of them in actual operation this year.

Cheap Power for Telephone Despatching

SEVERAL telephone train despatching circuits on western roads are being operated at a greatly reduced cost for power through a system developed and patented by Archibald Wray, assistant superintendent of telegraph, Chicago, Rock Island & Pacific, Chicago. A motor-generator set connected to a commercial source supplies direct current at a voltage suitable for the line. This generator is normally connected to a bank of condensers having a capacity of about 4 microfarads for each selector on the circuit. The connection to each terminal of the condensers is made through a front point of a relay which is so controlled by a master selector as to reverse these connections when a call comes in from the line, allowing the condensers to discharge and operate the circuit as indicated in the accompanying diagram. The current so produced has no effect on grounded telegraph circuits, simplexed on the telephone circuit. Since the connection between generator and condensers is normally closed and between condensers and line normally open, only the amount of current which is actually required to operate the selectors is consumed. This is found to be very small and on one road that has installed this system it is estimated that the annual cost for power will be less than $1.00.

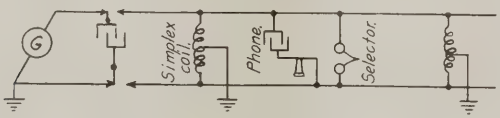

Fig. 1—Simple Connection Diagram of a Telephone Despatching Circuit Showing Use of Condensers with a Direct Current Supply.

Another power supply system devised and put in service on the Rock Island by Mr. Wray utilizes alternating current through a chemical rectifier. In this system the commercial alternating current power is transformed to any desired voltage depending on the number of selectors to be operated on the circuit and is then passed through a chemical rectifier which produces a direct current with very slight variation. This variation, however, was found to produce a hum in the telephone receivers and to overcome this an impedance coil was installed and condensers shunted across the circuit supplying the line. It was found that the impedance coil serves the purpose better than the condensers, however.

A second coil, shown in the diagram, serves to smooth out the direct current impulse so as not to produce a sudden crack in the receivers. A relay is provided in the leads to the primary coil of the transformer and also a relay in each lead from the rectifier to the line, all of which are operated by the master selector so that there is no chance for power to be consumed except when required for the operation of a selector.

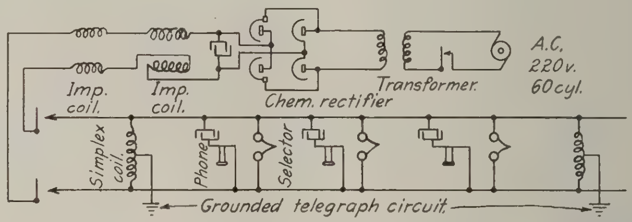

Fig. 2—Simple Connection Diagram of a Telephone Despatching Circuit Showing Use of Condensers Where the Direct Current is Obtained from an Alternating Current Supply Through a Chemical Rectifier. Impedance Coils Are Used to Smooth Out the Direct Current Impulse.

On the Illinois division of the Chicago, Rock Island & Pacific the telephone despatching circuit of 175 miles has been equipped with this system, replacing 166 cells of dry battery. About ½ ampere is required on the 220-volt alternating current circuit for each call during a period of about 3 seconds. As there are about 250 calls per day on this line, the power consumption is 110 watts for 12½ minutes per day or 8½ kw. hr. per year. At commercial rates this costs less than 50 cents per year. Careful estimates show that it will cost about $1.50 per year for chemicals in the rectifier and $1.00 per year for new aluminum elements or about $3.00 in all as compared with at least 275 dry cells at 25 cents apiece or $68.75. The rectifier and condensers cost $25, the transformer $4.25, additional impedance coils $10, or a total of about $40 for the equipment, and an estimated cost of $5 for the labor of installation.

Shop Motor Section

XXI—Electric Meters

J. H. Wickman*

THE object of this article is to explain the different electrical instruments that are used to measure electrical energy. The three most important of these instruments are the voltmeter, ammeter and the watthour meter, each of which will measure its particular part or a whole of the energy. The voltmeter will measure the volts or pressure, the ammeter will measure the amperes or current and the wattmeter will measure the watts or true power.

There are special meters such as the power factor meter, frequency meter, oscillograph and the synchroscope that perform special functions in connection with electrical measurements that will receive consideration later. Another object will be to place before the student a thorough description of each of the different kinds of meters, touching upon its construction, installation, repairs and operation, together with such practical points that will be of benefit to the electrician that handles electrical instruments on the railroad.

Definitions

The unit of current strength used in practical electrical measurements is called the ampere. A current is said to have a strength of one ampere if it will deposit exactly 0.001118 grams of metallic silver in one second when flowing through a solution of nitrate of silver and water. The resistance which the current encounters in flowing through any substance, such as a wire or a solution is expressed in the terms of a unit known as the ohm. One ohm is that resistance which is encountered by a current flowing through a column of mercury 106.3 centimeters long, weighing 14.4521 grams at a temperature of 32 degrees F.

The pressure which forces the current through the resistance is called electro-motive force or difference of potential and is measured in volts, one volt having the strength to force one ampere of current through one ohm of resistance. Electrical energy or power is measured in watts, which are equal to the volts multiplied by the amperes when considering direct current, and volts times amperes times power-factor times constants when considering alternating current. If one watt is used for one hour we would say that one watt hour of energy has been expended, but this being a very small quantity the unit of measurement is expressed in kilowatt hours, that is, 1,000 watts used for one hour is equal to one kilowatt hour. This unit is adopted as the universal unit for selling or buying electrical energy and all up-to-date watthour meters are being so made that they record in kilowatt hours direct.

Galvanometers

The first means that were used to measure electricity was by the use of the Galvanometer, which served the purpose quite satisfactorily and accurately, and as this instrument is still in use to a certain extent in laboratories for detecting and measuring very low currents it seems advisable that the student should know and master the principles of the galvanometer.

When a wire or a coil of wire is placed in a position parallel to the magnetic axis of a compass needle and current is passed through the coil of wire the needle will have a tendency to take a position at right angles to the coil or conductor and it is on this principle that the galvanometer is based. The ordinary galvanometer is made in two forms, one form having the magnetic needle suspended over a scale marked in degrees which rests on the coil, while another form has the needle suspended upon a jeweled cup, within the coil. In either case when no current is flowing through the coil the needle should rest in a position parallel to the coil, being held there either by the earth's magnetism or by some permanent magnet placed near the needle, but when any electricity is passed through the coil the needle will be deflected, the deflection depending upon the strength of current passing through the coil, that is the greater the current the greater the deflection. The degree scale is calibrated for different localities with standards equal to the standard unit of current, or the ampere.

Ammeters

As before stated the ammeter is used to measure current strength and all commercial instruments, whether for stationary or portable use, are so calibrated as to read in amperes. The principle of operation of most all direct-current ammeters is as follows: The current passing through the main coil produces a magnetic field which acts on another small coil or needle which tends to move, but being pivoted it turns on its axis and moves the indicating hand across the scale in opposition to the tension of a spring or to gravitational forces. In nearly all ammeters a permanent magnet surrounds the movable element.

Astatic Instruments

There are three essential characteristics that all instruments should have when used to measure current which are not possessed by all instruments in use. (1) They should indicate accurately regardless of external influences. (2) They should be dead-beat and retain their calibration indefinitely. (3) They should permit repairs without difficulty.

The principle of action of the Thomson astatic ammeter, which is used extensively for switch-board work because it possesses the above characteristics, is as follows: The fields of the instrument consist of an electromagnet, wound for any special voltage and provided with separate binding posts from the current posts of the instrument. The movable coils are mounted upon an aluminum disk and are located in a magnetic field which is parallel to the shaft and astatically arranged. Two small pieces of magnetic metal are rigidly mounted on the shaft, and the astatic components of the magnetic field, which are perpendicular to the shaft, tend to keep the pieces of magnetic metal in their initial position. When current passes through the coils of the movable element the lines of force parallel to the shaft produce a torque which tends to turn the shaft which is attached to the indicating needle. This action is opposed by the magnetic field at right angles to the shaft, acting on the two pieces of the magnetic metal. The calibration of this type of meter is of a lasting nature as the accuracy of the meter is not dependent upon the magnet strength. The magnet strength may change but the distribution of the field cannot change, hence the instrument is very accurate.

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Oftentimes instruments are purchased and used that are affected by external fields, which are common around a power house. The astatic instruments, however, are not affected by such stray fields, as the instruments are enclosed in an iron case and even if such a field did enter it would only tend to increase the torque on one side of the armature and decrease it on the other side, thereby producing a balanced effect.

Connections of Ammeters

When the current to be measured is small the main line carrying the current is connected so that the ammeter is in series with the line. On the other hand, when a large current is to be measured it would be impractical to build an ammeter that would have terminals large enough to connect the main leads to and the inside windings would be so out of proportion that such a meter would occupy too much room on a switchboard. To overcome such a cumbersome meter, therefore, a shunt is connected in series with the main circuit and only a portion, usually but 5 amperes, with full reading on the ammeter, is carried through the meter itself.

A word of caution relative to connecting any direct-current ammeters may be appropriate. If the meter is to carry the main line current the connections must be tight and clean so as not to heat up the terminals when a load is placed on the circuit. If the ammeter is used with a shunt, the flexible leads should never be cut. No doubt more cases of trouble have been caused by cutting off the leads sent out with shunts for ammeters than any other cause, this being done to make a neat appearing job of wiring. It should be remembered that the leads sent out by all meter manufacturers with the shunt for any particular meter are used when the meter was calibrated and the resistance of the leads was taken into consideration. Therefore the length of the leads should not be reduced under any circumstances if the correct reading is to be obtained. Another thing, the special numbers that are always stamped upon a shunt should correspond to the numbers on the meter with which it is used. Whenever connecting an astatic ammeter it must be remembered it will be necessary to run a potential circuit to each instrument for supplying the magnetizing coil as shown in Fig. 72.

A definite rule to remember when using the astatic ammeter is that whenever the top binding post of the magnetizing circuit is positive the top post of the current or measuring circuit is also positive. If it is desired to connect an ammeter to some circuit where there is a reversal of the main current at different times, it will be necessary to reverse the readings of the ammeter. This can be done by reversing the two leads from the shunt or by reversing the magnetizing leads.

Instruments of this kind have a long indicating hand which is always wedged at the factory to keep it from swinging while in transit. The cover of the instrument should always be taken off before installing and the wedge removed. Then the current should be put on the magnetizing coils at which time the indicating hand should stand at zero. If it does not it should be straightened until it does indicate correctly.

Troubles

There are few troubles that ever occur with this type of instrument, providing the magnetizing circuit is provided with a winding that will withstand the applied voltage. The one trouble that does occur is an open circuit in the magnetizing circuit and this is corrected by closing it. Should there be a poor contact between the shunt and the leads going to the ammeter the meter will not indicate correctly, therefore great care should be always taken while installing an ammeter to make sure that the surfaces are smooth and clean. A meter of any kind should not be placed where there will be excessive vibration as the moving element is usually set upon a delicate jeweled bearing. Such vibration is not only liable to crack these jewels but it might throw the small shafts out of their settings. It would then be necessary to remove the cover, unloosen the bearing and replace the shaft in it. Great care should be taken whenever working on a jewel bearing not to tighten it too tight and crack it. If the jewel should be cracked it would be necessary to replace it with a new one before accurate readings could be obtained.

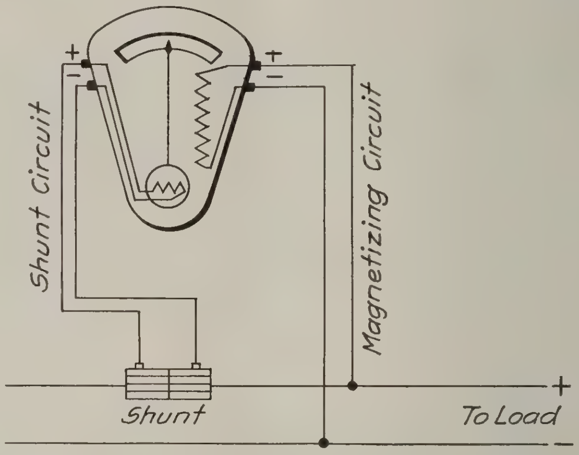

Fig. 72. Diagram of Connections for an Astatic Ammeter Showing the Potential Circuit for Exciting the Magnetizing Coil.

Alternating Current Ammeters

There are several makes of alternating current ammeters but the Thomson incline coil meter is one of the best and most used for station work. The essential part of this instrument is the stationary coil mounted with its axis at an incline and a vertical shaft or spindle carried on a jeweled bearing. On this shaft is a thin vane of iron mounted at an oblique angle to the shaft, also a pointer or hand which indicates the reading on the graduated scale. The spindle is also attended by a spring, its tension having a tendency to hold the pointer to the zero position. At zero the iron vane lays nearly across the axis of the current carrying coil, but whenever current passes through the coil it tends to turn to a position parallel to the axis of the coil, thus swinging the pointer across the scale.

Connections

The connections of all alternating current ammeters is on the same principle as those of the direct current ammeter, however, there is another factor that limits the passing of the main currents through the meter when measuring alternating currents, and that is the voltage. Should a system be operating on a high potential it would be unsafe and unwise to run the main feeders to the switch-board ammeters, therefore the current transformer, which was described under the head of transformers (Lesson XIX), is used to reduce the current so that only a proportional part of it at low voltage is carried to the measuring instrument. The diagram of connections shown in Fig. 73 shows the different ways of connecting an alternating current ammeter.

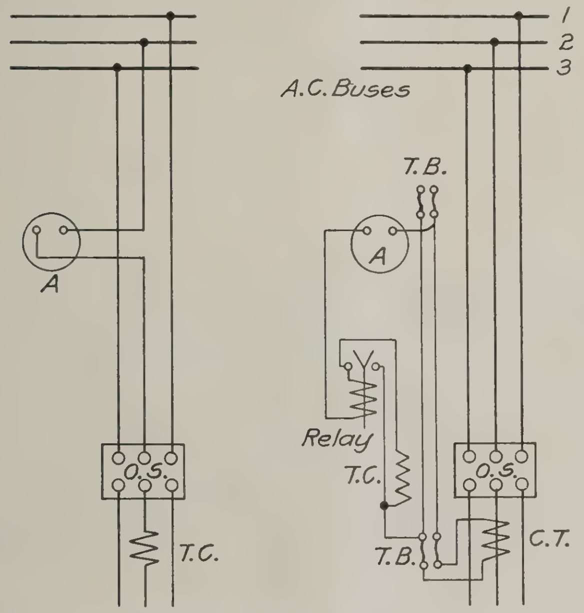

Fig. 73. A Diagram of Connections Showing the Different Methods of Connecting an Alternating Current Ammeter. At the Left the Ammeter Is Simply Connected in Series with the Middle Phase of a Three Phase System While at the Right the Ammeter Is Shown Connected in Series with the Secondary of a Current Transformer and an Overload Relay Which Latter Serves to Insert Resistance in the Ammeter Circuit on Heavy Overloads Thus Protecting the Meter. The Relay Is Not Necessary; It Simply Provides an Additional Protection.

The diagram at the left shows the ammeter (A) connected in series with the middle lead on a three phase system. Whenever this connection is used the voltage is low, around and below 1,000 volts. The amperage in each of the other phases or lines would be the same providing the system was operating on a balanced load, but if it were a lighting load and any one phase was unbalanced, that is, carrying a different amount of current than either of the other two phases, then it would be necessary to place an ammeter in series with each phase or line if the true amperage in each line was required. It is common practice and is recommended to have an ammeter in each line on all systems of any size, but usually the former installations were put in with only one ammeter to indicate the amperage of the line. The diagram at the right in Fig. 2 shows the connection where a current transformer (CT) is used to reduce the current to a low quantity, 5 amperes is usually the full load amount on the secondary side of all current transformers. With such ammeters as would be used in a connection like that shown the full secondary current would cause a full scale deflection of the pointer and would also indicate the main line current and not the secondary current of the transformer, that is, the ammeter is calibrated to show the primary current of the main line. The other portion of the wiring is the relay connection which is provided to automatically operate the oil switch on an overload. The relay will be fully described later.

Where a single phase current is used it is necessary to use but one ammeter under any conditions, but where a two phase current is used it is the practice to install one ameter in each phase. It would also be necessary on an unbalanced three phase system to have more than the one ammeter and current transformer.

Recording Ammeters

Another type of ammeter, known as the recording ammeter, is used for making a continuous record for each day, so that if desired the load carried at any particular time may be read from the chart. This meter is most used in central stations for checking the loads on any particular feeder or machine.

This instrument is also made portable and is made to operate on either alternating or direct current. The construction consists of a clock mechanism and the measuring element which is usually set on a ring stone and an end stone jewel so as to have as little friction as possible and at the same time to make sure that the pen is always in the correct alinement. The electrical element is of a solenoid type with gravity control. The indicating needle is rendered dead beat by an aluminum damping disc, which is operated from the armature shaft through gears so that a small movement of the armature operates the marking pen over a wide range. The charts used upon the meter are for 24 hours so that a complete record is made of the apparatus to which this meter is connected in series and the exact amount of current at any time of the day can easily be taken from the chart.

These meters, like the stationary type of instruments, are also made so that only the current from the secondary of the current transformer passes through the meter, but are calibrated so that the main line current is recorded. Another special feature used in connection with some types of recording ammeters is another style of damping device, which is used to prevent sudden overloads from throwing the recording pen off the chart, this being nothing more than a thin vane fastened to the pointer which moves through a small case filled with oil. Particular attention should be taken when setting the meter to loosen the movable element, place meter perfectly level and fill the damping device, if it has one.

The damping device of all of the horizontal edgewise instruments, whether ammeters, voltmeters, frequency meters or power factor meters, is effected by Foucault (Eddy) currents, which are induced in a piece of aluminum, attached to the indicating hand or pointer, as it swings between the astatically arranged magnets.

Voltmeters

There are several different methods of measuring voltage, namely, by spark-gaps, electro-dynamometers and the voltmeter, but the latter is the most used. However for measuring very high voltage the first two methods are in common use. Voltmeters are of the alternating and direct current types although many instruments will correctly indicate on either. No distinction will, therefore, be made in this article. The voltmeter resembles the ammeter in many respects, the only difference being that in many makes the voltmeter has an extra resistance coil in series with the movable element which is also of a smaller size wire. This coil or resistance is always enough to allow the voltmeter to be connected across the circuit. Certain types of meters have two resistance coils in series when designed for higher voltage and others often have an external resistance. Whenever external resistance coils are used the meter is calibrated with them, they are numbered the same as the meter and they should not be used with other meters unless the meter is recalibrated. There is also a type of voltmeter known as the differential voltmeter which has three leads entering it, two being positive and the other negative, the latter being connected to the middle point of the coil. Meters of this type usually have three resistance coils, one in series with each lead entering the meter.

The principle employed by most voltmeters of the induction types necessitates a rotating field or a split phase, the magnetic flux being driven across an air space or gap of high reluctance. To overcome this the International voltmeter was designed on a repulsion principle, that is, the primary which is connected across the lines is assembled with an inductive relation to the short-circuited secondary, the secondary tending to move whenever potential is applied to the primary. As the flux has a laminated iron path, only a small amount of current is necessary to cause a torque as compared with meters having an air path, the ratio being about 2,000 to 1.

The damping is obtained in the same manner as heretofore mentioned, that is, by a vane passing between the poles of a permanent magnet.

Portable Voltmeters

The portable voltmeter like the portable ammeter is used where it is necessary to take readings away from the power house or out on a pole and for checking with other meters. The construction is a permanent magnet surrounding the movable element which carries the small current that passes through the instrument. The uses in detail will be again spoken of under another head.

Special Connections

In large stations where the voltage of several different feeders or machines is wanted at intervals throughout the day a special voltmeter connection has been adopted as standard so that one meter can be used for taking the several readings, the connections for wiring are shown in Fig. 74.

The voltmeter bus circuit (ML) is run the entire length of the switchboard, so that where feeders or different machines make connection a tap is also made to the voltmeter bus, the circuits being broken by the voltmeter plug receptacles, as at (P). Each line is provided with a fuse block (F), so that in case of a short circuit anywhere on the voltmeter bus no damage will result. Whenever the voltage of any feeder is wanted a plug is inserted that completes the circuit as shown by dotted lines at (P). This same system is used for alternating and direct current systems, works out nicely in actual practice and is well recommended. It will be remembered, however, that where any very high potential alternating current is used potential transformers must be used, in which case the voltmeter will only indicate a proportional part of the main line voltage unless it is calibrated to read the high tension line voltage.

Troubles

The two principal troubles that could occur to a voltmeter would be a short-circuit in the windings or an open circuit. The latter occurs most often, and if the open is found it is easily repaired unless the meter is burned out, in which case the coil would have to be replaced and the meter recalibrated. Whenever a plug system is used, as shown in Fig. 74, it is always advisable to make sure that the fuse plugs between the meter and the feeder have not blown before attempting to take the meter apart and look for trouble.

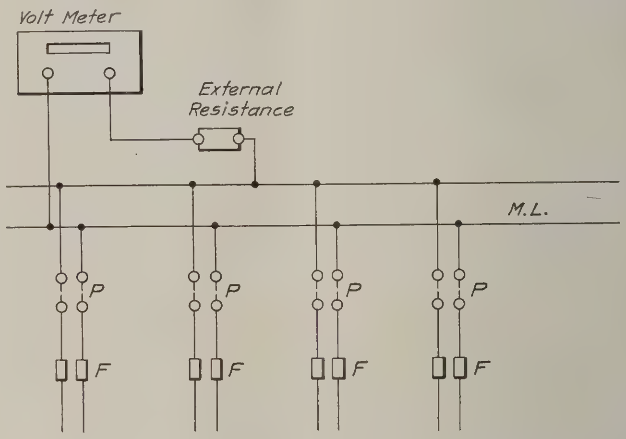

Fig. 74. Diagram Showing the Method of Connecting the Voltmeter on a Large Central Station Switchboard So That the One Meter Will Register the Voltage of Any Feeder Circuit Desired by Inserting the Voltmeter Plug in the Proper Plug Receptacle.

As the voltmeter is very delicate, the armature or movable element is easily displaced whenever there is a severe jar; such instruments should therefore be placed where there is as little jar or vibration as possible if accurate readings are desired. With good care an instrument should not require recalibrating or it should not be necessary to give much attention to the jewels oftener than once a year.

The special uses of electric meters will be taken up in the next article.

Utilizing Spoiled Munitions.—At the outbreak of the present war many manufacturers went into the munitions business without definite ideas as to the requirements of this work. Consequently a large amount of material was spoiled or made in such a way that it would not pass inspection. One concern lost over 5,000 18-lb. British cartridge cases, but a novel use was made of these cases. They were placed in a punch press and smashed down so as to form a shallow cup. Soldered on the edges of this cup were two small curved holders which converted the cartridge case into a very satisfactory and attractive cigar and ash holder. The result was that the spoiled cartridge cases sold for a higher price in this form than they would have if sold for munition purposes.—*Machinery.*

A. B. C. Car Lighting Course

Lesson No. 54

The Stone-Franklin System

IN the last two lessons we covered the theoretical operation and the details of construction of the Stone-Franklin Car Lighting System, and in this lesson and the next we will cover the maintenance of the equipment. This lesson will be devoted exclusively to the maintenance of the generator, including the suspension.

From the two previous lessons it will be remembered that no electrically controlled regulating apparatus is used in connection with the equipment, and, therefore, the maintenance is considerably simplified. The yard electrician, however, should look out for the following important items in connection with the maintenance of this equipment:

Output Adjustment

When the Stone-Franklin equipment is operating in connection with an ampere hour meter control panel, it will be found that by setting the output at "normal," as indicated by the output indicator, the requirements of the car to be lighted will be taken care of. With equipments which do not have an ampere hour meter panel the minimum necessary output of the generator will vary according to the amount of lighting needed for the service in which the cars are working. The required minimum generator output under such conditions is easily determined by volt meter and specific gravity readings taken at regular intervals. It would be advisable to take such readings as often as possible, not less than once a month.

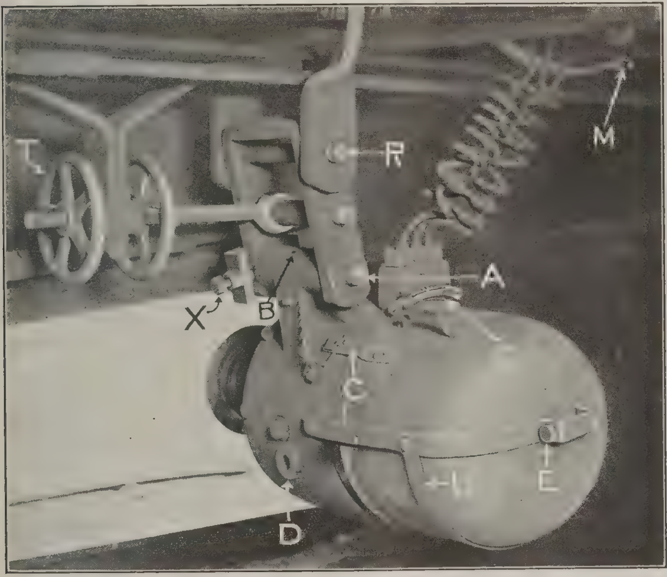

Fig. 1. View Showing a Stone-Franklin Car Lighting Generator with Its Suspension as Applied to a Modern Steel Car. The Belt Tension Is Adjusted by the Hand Wheel T and When Applied New the Belt Should Be of Such a Length as to Pull the Generator Towards the Driving Pulley So That the Dynamo Suspension Pin A Is Inclined Two Inches Toward the Axle Pulley with Relation to the Top Suspension Link Pin R. The Output Indicator Is Shown on the Terminal Block. By Tightening the Hand Wheel T So as to Draw the Suspension Link to the Left, Facing the Commutator End of the Machine, the Output of the Generator Is Increased, the Amount Being Indicated on the Output Indicator Which Is Calibrated in Amperes. To Reduce the Output the Hand Wheel Is Slackened.

The output indicator, located on the front of the machine, serves to indicate the belt tension accurately for any desired output. This output indicator is based on the principle of a spirit level and indicates primarily the angular position of the generator. It is calibrated into terms of amperes, and by referring to Fig. 1 it is evident that by tightening up hand wheel T the output of the generator is being increased and the amount is readily indicated on the output indicator. To reduce the output of the generator, hand wheel T is slackened. Always make sure that the hand wheels are securely locked.

The ampere hour meter panel referred to above serves to make the generator inoperative when the necessary number of ampere hours have been replaced in the battery.

Belt

By referring again to Fig. 1 it can be seen that two adjustment brackets X are provided in the suspension link of the generator by which the machine can be adjusted to make the belt run in the center of the pulley at all times.

With this equipment the Walker fastener is used exclusively, and it should be examined carefully to see that the pins passing through the links of the fastener are in place. If it is found that the joint is cracking, a new piece can be inserted in the belt, which, however, must not be less than one foot in length. When it is found necessary to apply a new belt, the correct length of the belt is indicated on an instruction card placed in the locker. If such information is not available, care should be taken that the belt is of such a length that the dynamo suspension pin A, Fig. 1, in the link is 2 in. out of perpendicular with relation to the top or suspension link pin, inclination to be toward the driving pulley. The generator suspension pin A is fixed in the suspension link by a key so that the generator swings on it, the suspension lug forming a large bearing for this purpose, which occasionally, say once every two months, should be lubricated through the hole B provided on top of the suspension lug.

The standard belts for the Stone-Franklin equipments are:

T–35—2½" wide, 4-ply
T–50—4 " " 4-ply.

Motoring Generator

To motor the generator follow the detailed instructions given on page 435 of lesson 53, in the July issue, to which can be added that by placing a short 1-in. bar into hole D, Fig. 1, provided for this purpose, the machine can be more easily levered forward in order to remove belt.

Commutator

It is advisable to occasionally remove the commutator and dust cover in order to thoroughly inspect the commutator and the pole changer. To take the dust cover off, remove pin from safety catch C, Fig. 1, and raise the fixing straps U toward the top, as shown in Fig. 3, after which the front dust cover is easily removed.

It will be noticed that an adjustment can be made in the fixing straps by screw E, Fig. 1, which serves to tighten the strap on the dome as may be required.

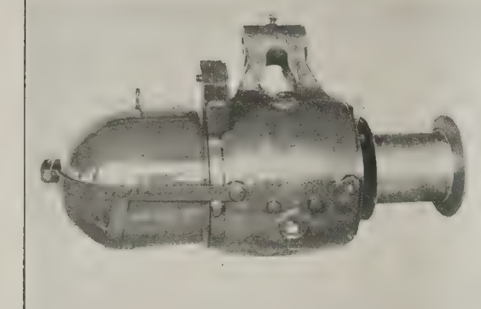
Fig. 2

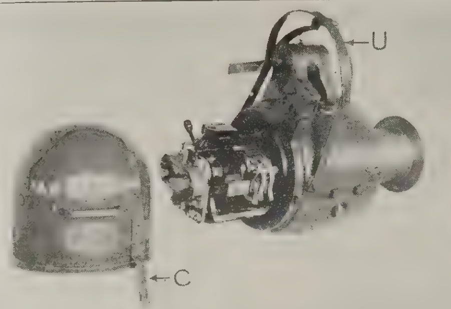

Fig. 3

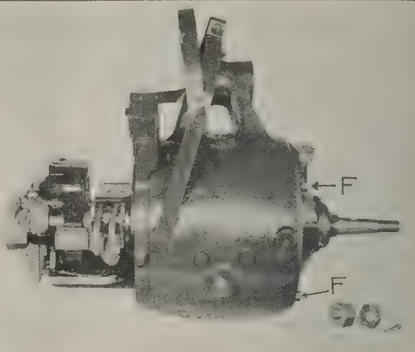

Fig. 4

Fig. 2 Shows a View of a T-35 Generator Complete as It Appears When Removed from Its Suspension on the Car Body. The Plug in the Top of the Suspension Lug Indicates Where This Bearing Is Lubricated. To Remove the Commutator End Dust Cover at the Left, Take Out the Pin from the Safety Catch C (See Fig. 1) and Raise the Fixing Strap U as Shown in Fig. 3. The Pulley, Which Is Applied on a Standard Taper Shaft, Is Removed by Taking Out a Split Pin and Unscrewing the Two Nuts Shown in Fig. 4. Next the Four Cap Screws F Are Unscrewed and the Brush Tension Levers Loosened So That the Armature Complete with Bearings and Back Head Can Be Removed As Shown in Fig. 5. With This Arrangement an Armature Can Be Replaced in One Minute.

The commutator usually needs no attention, except an occasional wiping with a piece of clean waste or rag.

Pole Changer

Care should be taken that the adjustment of the brushes is not disturbed. By rotating the armature by hand the friction of the brushes must be sufficient to engage the contact arms with the small brushes, known as the excitation brushes. When the machine is inoperative the negative main brush must not touch the extension contact arms. The details of the pole changer were illustrated and fully described in the previous lesson.

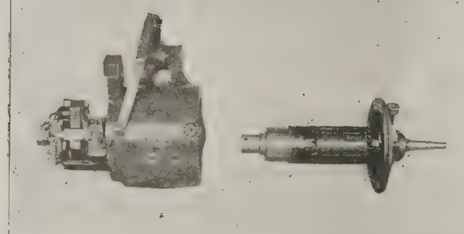
Fig. 5

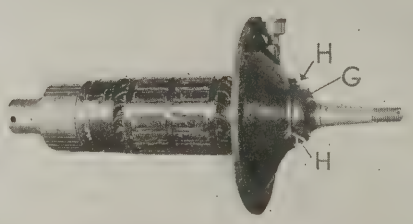

Fig. 6

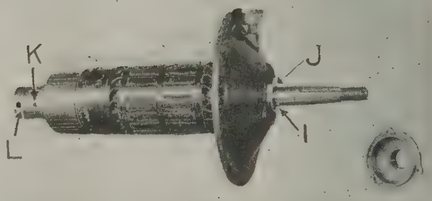

Fig. 7

The Armature Complete Is Shown Removed from the Generator in Fig. 5, a Larger View Being Shown in Fig. 6. The Next Operation Is to Take Off the Pulley End Dust Cap E, Fig. 6, by Loosening the Three Cap Screws H. After the Shaft Key Has Been Removed the Dust Cap Can Be Slipped Off as Shown in Fig. 7. The Bearing Lock Nut J Is Now Exposed. It Is Removed by Unscrewing the Set Screw I Which Binds the Lock Nut on the Threads. After the Set Screw Has Been Loosened the Lock Nut Can Be Unscrewed from the Shaft With an Ordinary Spanner Wrench Which Fits Two Flat Spots on the Lock Nut.

Ball Bearings

As mentioned in the last lesson, each bearing is provided with a grease lubricating cup in order that a small quantity of fresh grease can be supplied to the bearings as necessity arises, without having to remove the armature or uncover the bearing caps.

Although every screw in connection with the equipment is locked by means of lock washers or grip nuts, it is advisable to periodically examine all screws, bolts and nuts and make sure that they are tight. This applies particularly to the suspension of the generator axle and generator pulleys.

With such maintenance it will only be necessary to give the machine a complete overhauling every time the car goes into the shops for general overhauling. The machine should then be dismantled from the car by removing suspension pin A, and care must be taken to see that the pin is driven out from the side on which the adjustment bracket is fixed, as the key in the pin is fixed in the other end.

A general view of the machine complete as removed from the car is shown in Fig. 2, which incidentally clearly shows the screw plug fitting into the oil hole at the top of the suspension lug provided for lubricating this bearing.

Dismantling the Generator

The first operation is to remove the dust cover, as shown in Fig. 3. This is accomplished as previously described under "Commutator."

Pulley

The next operation is to remove the pulleys by removing the split pin and the two nuts on the end of the shaft. A view of the generator with the front dust cover of the pulley removed is shown in Fig. 4.

Since the pulley and shaft are in accordance with the rule of the Train Lighting Committee of the Master Car Builders' Association (see Fig. 2, page 420, of the July issue), the standard pulley puller can be used if found necessary when removing the pulley. This pulley, however, necessitates the use of a special type box spanner wrench to either secure or loosen the pulley nut and lock nut.

Armature

The armature complete, with bearings and back-head, is next removed by taking out the four ⅜" cap screws, F, Fig. 4, which secure the back-head to the frame of the generator. When these cap screws are taken out, and after the brush tension levers have been raised, so as to loosen the brushes on the commutator, the armature complete can be easily taken out by hand, as shown in Fig. 5. The armature complete, as it is removed from the machine, is shown in Fig. 6.

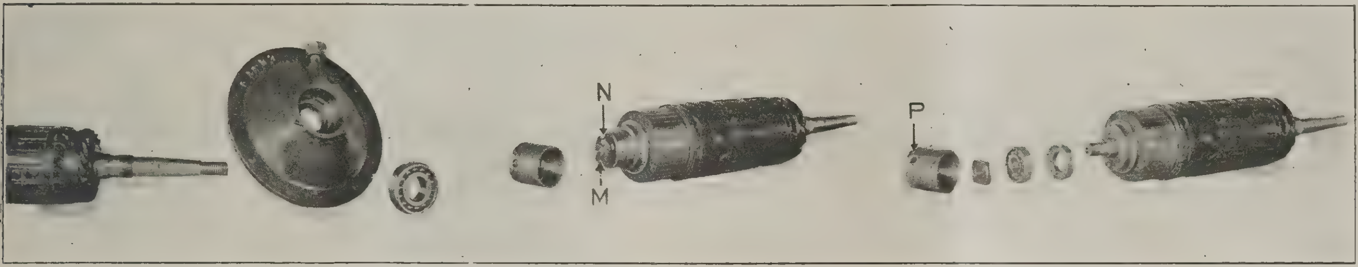

Fig. 8 Fig. 9 Fig. 10

Upon Removing the Bearing Lock Nut the Back Bearing Head Together with Its Bearing Can Be Removed as Shown in Fig. 8. Here the Bearing Is Shown Separate from the Head, but They Are Both Removed Together. The Next Operation Is to Remove the Commutator End Bearing by Unscrewing the Two Set Screws K in the Front Housing L, Fig. 7.. After the Housing Is Removed as Shown in Fig. 9, the Bearing Lock Nut M Can Be Unscrewed After Loosening the Set Screw N, Fig. 9. It Is Now Possible to Remove Both Bearing and Grease Groove Ring as Shown in Fig. 10. The Hole P in the Housing Admits Grease into the Bearing.

Pulley End Dust Cap

The next operation is to remove the pulley end dust cap G, Fig. 6, by loosening the three cap screws, H. It will be necessary, however, to remove the shaft key before this cap can be slipped off of the shaft. This dust cap is shown removed in Fig. 7, and also the lock nut which locks the back pulley end bearing in place. To remove the back bearing head, loosen the lock nut set screw, I, Fig. 7, and remove the lock nut, J, with an ordinary spanner wrench which fits the two flat surfaces. After removing the lock nut the back bearing head is easily removed, as shown in Fig. 8. In the figure the bearing is shown taken out from the head, but, of course, the bearing and the head come off together.

Commutator End Bearing

The next operation is to remove the commutator end bearing. This is accomplished by unscrewing the two set screws, K, in the front housing, L, Fig. 7. With these sets screws removed, the housing is easily removed, as shown in Fig. 9. The bearing lock nut, M, is now exposed, which can be removed by loosening the set screw, N, Fig. 9. When the set screw has been unscrewed from the shaft with an ordinary spanner wrench which fits the flat surfaces of the nut, it can be removed from the shaft together with the ball bearing and grease groove ring, as shown in Fig. 10. In regard to both bearings it is important that both ball bearings should be left permanently in position on the shaft, as their removal tends to impair their fit. Only when absolutely unavoidable should these bearings be removed, as it will be possible to clean and inspect them in place. The view of the front housing, the bearing lock nut, the bearing and the grease groove ring is shown in Fig. 10, and particular attention is drawn to the two lubricating holes, P, in the front housing which engage with the grease groove in the front head so that in replacing the armature the location of these grease holes in the front housing is immaterial, as they will serve in any position to admit the grease forced into the bearings through the grease cup. The armature is now dismantled as far as will ordinarily be necessary.

When reassembling the machine, the ball bearing housings should be filled with grease. The manufacturers recommend "Special S. K. F. Ball Bearing Grease," as particularly suitable in connection with the bearings on these generators.

The maintenance of the switchboard and panel equipment connected with this system will be covered in the next lesson.

Swiss Railway Electrification

The general management and the standing committee of the Swiss Federal Railways have just submitted a report to the council of administration in regard to the projected electrification of the Erstfeld-Bellinzona section of the St. Gothard Railway. It is first pointed out that the three-phase system would be unsuitable for the purpose in view, while the advocates of the direct-current method base their contention on experience with lighter trains and pressures far below 3,000 volts. The single-phase system, which is already employed on the Lotschberg Railway, can now be recommended for adoption without reserve. No other electric railway exists which can be placed on an equality in regard to the varied nature of service, the number of locomotives, length of the track and extent of services rendered with that of the New York, New Haven & Hartford. At the same time this railway is the first which, owing to the system used, has proved itself to be extensible at will and capable of being accommodated to all kinds of services. In the case of the Lotschberg Railway, the interruptions in working were attributed chiefly to the difficult circumstances under which the electrical equipment had to be provided. The report also discusses the problem of uniformity in the form of current and periodicity, which it is sought to attain in the distribution of energy throughout Switzerland.—*Railway Gazette,* London.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Screens for Switchboard

The Sault Ste. Marie Bridge Company is operating the international bridges at Sault Ste. Marie, Mich., consisting of one stationary nine-span single track bridge and two movable spans across the navigable waterways. Both movable bridges are completely electrified, in other words, electric energy is used as the motive power for the operation and interlocking of these bridges.

As electricity is dangerous in the hands of the average man and, also, because it was desired to be in phase with the Safety-First movement, the circuit breakers, fuses and other live parts of the electrical apparatus on the bridges are enclosed so as to guard as much as possible against employees coming in contact with the live wires. The parts are enclosed in such a way as to make them visible to the operators, which is important when a fuse is blown or anything else goes out of order.

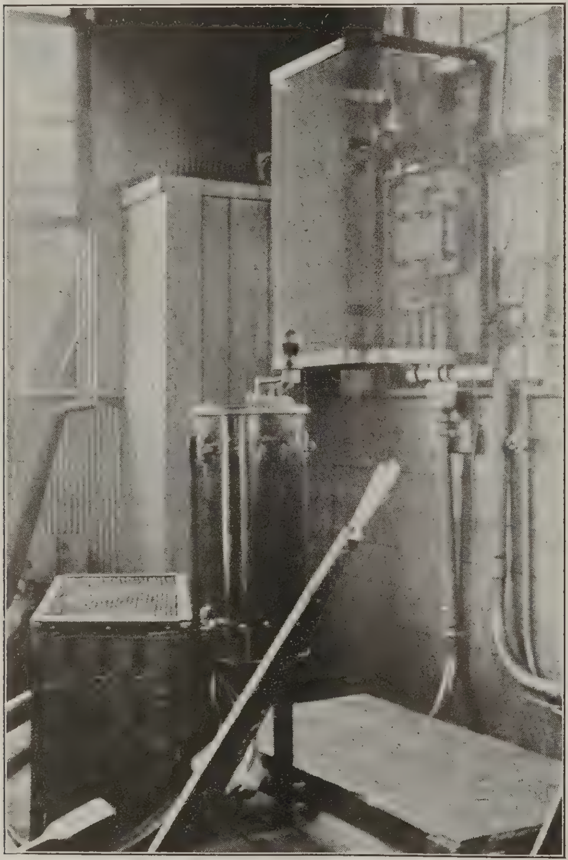

Fig. 1. View Showing the Screen Around the Incoming Power Line and the Main Circuit Breaker and Around the Resistance Grids.

The screen around the incoming power lines or main entrance and the main circuit breaker is shown in Fig. 1. The screen is open at both ends, but is arranged with hinges so that when the circuit breaker trips, in case of trouble, it may easily be opened like a door and closed again after the circuit breaker has been reset.

The resistance grids, used in connection with the controller, are totally enclosed with a special screen-like box which is seen near the controller in Fig. 1. With this arrangement it is impossible for the operator to come in contact with live parts.

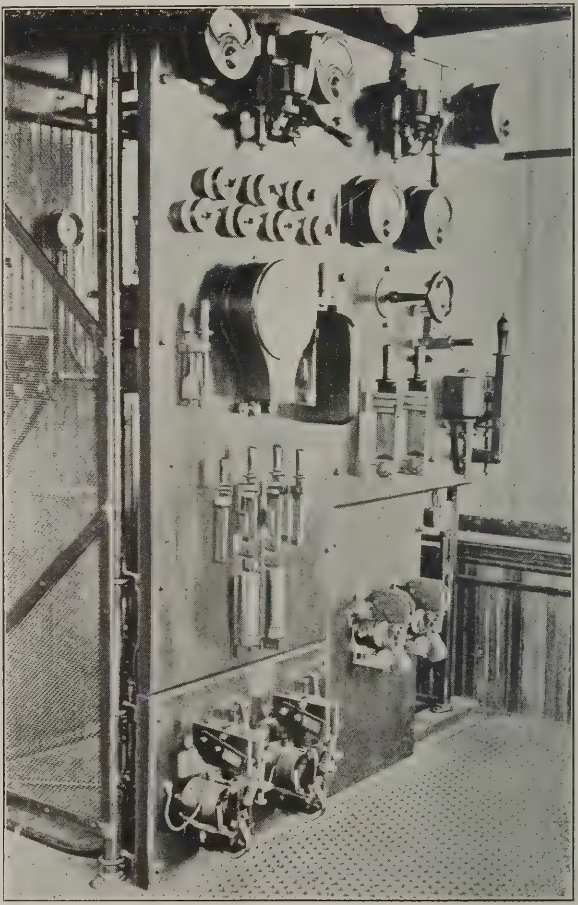

Fig. 2. View Showing Application of a Screen for Isolating the Rear of the Switchboard.

The main switchboard for the entire system, from which both bridges are operated, is shown in Fig. 2. Referring to this photograph it is seen that a suitable screen door with a lock is installed in such a way as to make it impossible for anybody, who has no business there, to go behind the switchboard, which is the most dangerous part.

Screens like those described cost but little and when properly applied make a large part of the electrical apparatus fool-proof, which makes it possible to break in a man with average intelligence to operate the bridge under the supervision of an electrical operating engineer.

J. G. Koppel,
307 South street, Sault Ste. Marie, Mich.

General News Section

The Long Island, in the five days of heavy traffic incident to the Fourth of July holiday season, moved 5,301 passenger trains with an average delay of 4 minutes, 33 seconds. The number of passengers carried in this period was 1,029,721.

The strike vote of the train and engine employees in the Eight-hour Day controversy was completed on July 26. The general chairmen of the eastern and southern roads met in New York on August 1, and those from the western roads are scheduled to meet not later than August 5 to count the ballots, after which another conference with the National Conference Committee of Railroads will be held, beginning August 8.

The employees of the Pullman Car Works, Pullman, Ill., have organized a baseball league to consist of 10 competing teams. J. S. Runnells, president of the Pullman Company, has offered a permanent cup for the winning team and a set of medals for the individual members. The company will furnish uniforms and all necessary incidental equipment. LeRoy Kramer, vice-president of the Pullman Company, has been made honorary president of the league; R. Thompson is president, C. Swingle, vice-president; E. A. Backlin, secretary-treasurer.

The Pennsylvania Pays Families of Employes in National Guard.

Distribution of the funds needed for the relief of the families and dependents of Pennsylvania Railroad employees who have been called into military service on the Mexican border commenced on July 31. The first installment of the relief money covered the month of July. Thereafter, payments will be made semi-monthly, as in the case of wages, and in all instances will be placed directly in the hands of the wife, mother or other beneficiary. This duty will be performed by employes designated by the various superintendents. The payments will be made out of the fund of $100,000 set aside by the board of directors for this purpose.

Bare Grounded Return Wiring Systems to be Investigated

The Committee on Electrical Wiring Systems of The Electrical Industry has appointed the following subcommittee to investigate Bare Grounded Return Wiring Systems:

Chairman, C. E. Corrigan, Associated Manufacturers of Electrical Supplies, Pittsburgh, Pa.; W. H. Flandreau, International Association of Municipal Electricians, Mt. Vernon, N. Y.; J. C. Forsyth, American Institute of Electrical Engineers, New York, N. Y.; G. S. Lawler, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.; C. Renshaw, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.; secretary, Wm. S. Boyd, Western Association of Electrical Inspectors, 175 W. Jackson Boulevard, Chicago.

The committee desires the co-operation of the entire electrical industry in this work, and to that end requests that all information and data on wiring systems having a bare grounded conductor, be sent to the secretary.

The Committee will especially appreciate the following information:

(1) Safety, cost and reliability data based upon practical experience with concentric wiring, or any other type of wiring having one or more bare or partially covered conductors which are permanently connected to earth;

(2) Theoretical or tested installation details or protective features which will safeguard concentric wiring or other wiring systems having bare grounded conductors;

(3) Reliable methods of preventing meter setters or linemen from reversing the polarities of a two-wire system;

(4) A suitable definition of "ground" or "earth" as these words relate to electric wiring;

(5) Practical experience with ground or earth connection;

(a) Whether they have been found reliable, or unreliable;

(b) The proportion found to be unreliable, if any;

(6) Adequate methods of establishing and maintaining a reliable ground or earth connection for safety purposes;

(7) A simple method of test which will insure the detection of unreliable ground or earth connections;

(8) Economics which may be practiced with safety in connection with any of the existing wiring methods;

(9) Estimates or actual figures as to the cost of any protective features reported upon in response to the foregoing request.

Arc Welded Machine Tools

Machine tools produced by welding high speed steel tips to machine tool shanks have been found by the Westinghouse Electric Mfg. Company to be very satisfactory. Electric arc welding has enabled them to turn out tools more satisfactorily and cheaper than by any other process, a conclusion reached after exhaustive tests employing oxy-acetylene and forging metals.

For best results the current used for this work is approximately 100 amperes and the voltage of the welding circuit approximately 60 to 70 volts. A 5/32 inch Norway iron electrode is used. The tools are pre-heated before welding, and annealed afterwards by being buried over night in mica dust or lime. They are then put through a process of heat treatment, which materially improves their cutting qualities.

A close record has been kept of this welding work and which shows that electrically welded tools will actually produce 10 per cent. more work than solid tools, before regrinding is required. This is believed to be due to the reinforcing metal which is built out and around the tip, serving both to give large radiating surface and to afford a larger conducting path back to the butt of the tool, thus keeping down the temperature at the cutting edge. At the present time practically all the tools for the lathes and planers used by the Westinghouse Company are turned out in this manner.

Personals

Charles B. Woticky.—In the July issue appeared a brief announcement saying that C. B. Woticky had been appointed electrical engineer of the Lehigh Valley and that E. J. Cartwright had been appointed assistant electrical engineer, both with offices at South Bethlehem, Pa. Mr. Woticky, who until recently was in the electrical department of the New York Central under H. A. Currie, received his preliminary education in the De Witt Clinton high school of New York City and in the College of the City of New York, also in New York City. Mr. Woticky received his technical training at Columbia University and was graduated from the electrical engineering course in 1908. He was chief operator for the General Electric Company plant at Schaghticoke, N. Y., and Johnsonville from 1908 to 1910. He then became associated with H. A. Currie, assistant electrical engineer of the New York Central, where he remained from 1910 to 1916. During this time he received a wide experience in electric traction, car lighting and general shop work. While with the New York Central, Mr. Woticky was also under Mr. Brett for two years on steel car construction and electric locomotive work and during part of 1911 he erected a power plant for the Regina Mining Company in Michigan.

Mr. Woticky's thesis in Columbia was on the Investigation of the Track Relay Used by the General Railway Signal Company for Alternating Current Signals. His work in connection with this thesis was done while he was with the New York Central and in this way he gained considerable experience in automatic train stop work as applied to steam roads and in telephone work from moving trains to land stations.

Akron, O., April.—It's an ill-wind, indeed, that hasn't a silver lining, as Josh Billings would say. In this case the silver lining played a double header. Some two score years ago a young and promising Easterner started for the Northwest, but tarried at Akron, Ohio.

So enamored did he become with the potential seat of manufactured rubber culture that he besought himself a newspaper job then and there. It being necessary to interview a brother of no less than Frank Pixley, the now eminent father of drama and musical comedy, in order to officially affix himself in the treasurer's good graces, our young Go-Wester journeyed to the aforesaid's home. Mr. Pixley was ill.

Before the interview had concluded itself, an Akron doctor, essaying the role of heavy villain, announced that the house was quarantined and that Mr. Pixley had the smallpox. Needless to state the young job aspirant remained as guest. And so in the course of time he joined the staff of the newspaper and was also joined in wedlock to Mr. Pixley's sister—hence the aforementioned double lining.

This is the story of how Mr. E. C. Tibbitts, who on April 7 concluded his 19th year as the one and only advertising manager which the B. F. Goodrich Company has ever had, reached Akron. He reached the Goodrich factory before they'd had a chance to hang the receiver back on the hook after calling up his paper and inquiring, "Have you a bright young man whom you could recommend to write advertisements?"

Trade Publications

The Nitrolyte House Organ.—The Harter Manufacturing Company, of 1132 West Austin avenue, Chicago, Ill., has just issued the first number of its new little house organ, "The Nitrolyte." This first issue is a breezy little number and contains many a laugh for those with a sense of humor and, at the same time, gives some real information on the Harter line of lighting fixtures.

The Edison Storage Battery Company, Orange, N. J., has prepared a new booklet on its storage battery. It is considerably more elaborate than any issued in the past and is profusely illustrated and contains a simple and concise explanation of the chemical action taking place in the Edison battery on charge and discharge. Complete data on train lighting batteries which will be of interest to railroad officers is also given.

A New Book, Free!—"One Hundred Condulet Suggestions" is the title of a new publication, just issued by the Crouse-Hinds Company, of Syracuse, New York. The book contains photographic reproductions of one hundred installations especially selected because of the excellent manner in which the wiring requirements of the different situations were met. These illustrations are indexed and sub-indexed in such a manner that no matter what form of conduit work engages the interest of an electrical contractor, it takes but a moment's time for him to turn to the page or pages in this book showing similar requirements which have been met in a thoroughly satisfactory manner. Each illustration occupies the upper half of a separate page, the lower half being taken up with explanatory reading matter and page references to a pictorial index of Condulets, which takes up nine pages in the back of the book. The index contains enlarged views of all the condulets and condulet accessories used in the one hundred installations. It also gives, under each view, detailed information as to the page or pages in the book where the article is shown installed, and likewise tells in what catalog or bulletin and on what page the condulet or accessory is listed. The book which is 6 in. x 9 in. in size contains 112 pages. It is printed on good quality enamel paper and is attractively bound. The Crouse-Hinds Company advertises that it will send a copy of this truly excellent book free of charge to anyone who is in a position to make use of it. We suggest that all who are eligible to accept this offer, do so, using the coupon attached to the advertisement which appears in another part of this magazine.

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Strike Hastens This Issue

Because of the serious aspect of the impending railroad strike, it was decided to get the September issue of the *Railway Electrical Engineer* in the mails before Labor Day, September 4. As this is a week ahead of our regular schedule, it was necessary to make a number of changes in our plans. It has been necessary to leave out the Shop Motor Section and the A. B. C. Car Lighting Course lesson. We feel, however, that it will be better to get the issue in the mails before the strike and insure delivery even though it is necessary to do this.

Regenerative Braking

Regenerative or electric braking, as used on the electrified divisions of the Norfolk & Western and the Chicago, Milwaukee & St. Paul, is a development in electric traction that is in a large measure responsible for the successful and economical use of electric energy for hauling heavy trains over mountain divisions. The advantages of electric braking in this class of work are so positive and the economies effected by it so real that there is no doubt but what the systems chosen for future electrifications, especially in mountainous districts, will be those in which this feature is successfully embodied. The advantages include the factor of safety, reliability, flexibility of control and simplicity of action, especially with long freight trains containing considerable slack, while the economies effected are reduced wear and tear on running gear and brake shoes and the fact that a large per cent of the power required to haul the train up-hill is returned to the transmission system when the train is going down-hill.

As is true with most all important developments and improvements, especially in electrical apparatus, the fundamental theory and the details of operation of the various schemes used for regenerative braking are more or less mysterious to the average man. For this reason, an article on "What Regenerative Braking Really Is" appearing in another part of this issue, is of special importance. The article will appear in two sections, the first, in this issue, covers direct current as used on the St. Paul locomotive, while the second article, which will appear in the October issue, will describe the details of regeneration with three-phase alternating current.

Illuminating Engineering Lecture Course

In the fall of 1910, the Illuminating Engineering Society, in co-operation with the Johns Hopkins University, held its first lecture course on the Science of Illumination; it is generally recognized that the proceedings containing these lectures include some of the most valuable information on record concerning the subject of illumination. Now, after a period of six years, during which there have been many changes in methods, improvements in apparatus, and developments in theory, the Illuminating Engineering Society will hold another series of lectures, this time at the University of Pennsylvania, Philadelphia, Pa.

The course will be given immediately after the convention of the Illuminating Engineering Society, to be held in the same city, and the lectures will be given in the Engineering building of the University. The course, which will cover the principles of illumination and various aspects of lighting practice, will include about twenty lectures by men selected on account of their qualifications to deal authoritatively with the various phases of the subject. In connection with the lecture course there will be an exhibition at the University of Pennsylvania of recent developments in illuminating appliances together with a novel lighting installation. There will also be an inspection tour of the various points of interest in and about Philadelphia, including manufacturing establishments. laboratories, lighting companies and notable installations. In addition to the above the tuition fee will include a reprint of all the lectures given, which will undoubtedly form a valuable addition to the libraries and reference data of those interested in illuminating engineering. A detailed announcement of the lecture course appears on page 488 of this issue. It will be seen from the list of subjects to be covered that a large number of the lectures will be of special interest to railway electrical engineers, and it is hoped that a representative number of them will be present.

Practical Stunts Competition

Your attention is called to the Practical Stunts Competition announcement on page 441 of the August issue of the *Railway Electrical Engineer*. The announcement stated that for the best practical stunt article that is not more than 500 words in length which is received in our office in the Woolworth building, New York, on or before October 1, 1916, we will give a prize of ten dollars. For the next best practical stunt we will give five dollars. Others which are accepted for publication will be paid for at our regular rate.

This competition has yet a month to run, during which time we hope all of our readers will contribute by sending in their ideas, with photographs and sketches if possible. We have received a goodly number already but we want more. Each railroad should be well represented in the competition and to this end we suggest that the heads of the various electrical departments on the railroads call the attention of their men to the competition and suggest that they go after the prize. Each member of the electrical departments has, undoubtedly, at some time, developed some device or system that has been of material assistance to him in his work; it is a description of such practical stunts which have helped you that we want to publish for the benefit of the other boys, so send them along regardless of whether they were developed yesterday or two years ago. They may be old to you, but nevertheless will probably be just what someone else is looking for. Remember the judges will base their decision on the practical value of the device or method, so the more practical your stunt is the better chance it will have of winning the prize.

We are hoping to get at least one practical stunt from each of our readers but nothing will please us more than to receive more than one from each. As we said in our first announcement, we don't expect elaborate essays; we don't care particularly as to whether the spelling and grammar are correct; we want the ideas, the rest can easily be taken care of. What will be your contribution? Don't let the month go by without sending in at least one. Remember that even if you don't get one of the two prizes, your contributions will be paid for at our regular rates if accepted for publication, which they undoubtedly will be if practical.

The Headlight Order

The recent order of the Interstate Commerce Commission regarding headlights for locomotives used in road and yard service requires that "each locomotive used in road service between sunset and sunrise shall have a headlight which will enable persons with normal vision in the path of the locomotive, under normal weather conditions, to see a dark object the size of a man at a distance of 1,000 ft. or more ahead of the locomotive." The order is applicable to all steam locomotives put in service subsequent to October 1, 1916, and to all steam locomotives given general overhauling subsequent to October 1, 1916, and requires that all steam locomotives subject to the rules be equipped in conformity therewith, not later than January 1, 1920. The question is, What kind of a headlight will meet the new specification? What should be its type, size and candle power?

The choosing of a headlight that will exactly meet these conditions is difficult in view of the fact that the order is sadly indefinite. It speaks of "normal vision," "normal weather conditions" and a "dark object" without giving a clear definition of either term. However, an article on meeting the federal headlight requirement published in this issue will be of material assistance in choosing equipment which will comply with the law. The article is based on all the information regarding locomotive headlights that is available and in addition to a discussion of the problem it includes a complete bibliography of articles and books on headlights which will be a valuable reference for those interested in the subject.

From our interpretation of the commission's order, a headlight with an apparent beam candlepower of approximately 1,000,000 will be required. This opinion is based on the Columbus tests of the American Railway Master Mechanics' Association made in 1914. At that time the only headlight which would give such a candlepower was of the arc type rated at 25 amperes 32 volts. It is quite possible that with the newer types of tungsten lamps, which give a white light, the beam candle power can be reduced somewhat as it has been demonstrated many times that the white beam produced by an incandescent tungsten lamp will pick up objects much better than the beam from an arc headlight.

It is interesting to note that during the Columbus tests it was demonstrated that a headlight with an apparent beam candle power of 1,000,000 increased the phantom lights from signals and semaphores to 33 per cent of all signals observed. The phantom lights began to appear with a beam intensity of 30,000 candle power and it seems that the committee is going directly against the experience of the Master Mechanics' committee in specifying conditions that require a headlight giving approximately 1,000,000 candle power.

The committee also failed to consider the different operating conditions prevailing on roads in various parts of the country. It has been conclusively shown in many tests, that headlights with an apparent beam candle power above 3,000 are dangerous on four track systems where trains are passing each other every few minutes.

Meeting the Federal Headlight Requirements

A Discussion Dealing with Incandescent Electric Equipment, and a List of Publications on Headlight Subjects

By L. C. Porter

THE recent Federal legislation* requirements governing locomotive headlights will unquestionably start an active search for literature, and probably cause tests to be conducted by various railroads in the immediate future, in order to determine the best method of meeting the new specifications. A brief outline of what has been accomplished and references to some of the literature already available, may be of assistance in solving the problem. It is not the intention of the writer to enter into a discussion of the merits or otherwise of the new ruling, but rather to describe equipment, including principles involved in its design and operation, which will comply with the law, and to suggest methods of test and desirable specifications for such equipment.

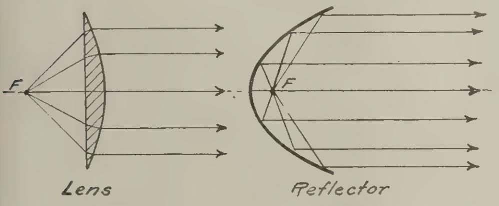

Fig. 1—Diagram Showing Projection of Light Rays from a Point Source Through a Convex Lens and Parabolic Reflector.

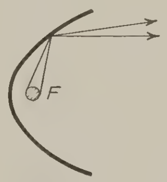

Fig. 2—Showing Projection of Light from a Spherical Light Source in a Parabolic Reflector.

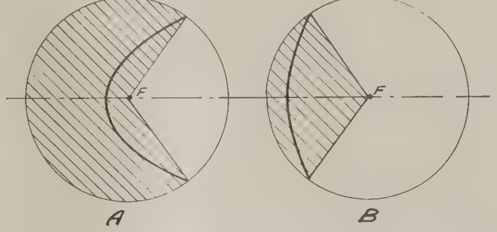

Fig. 3—Diagram Showing Amount of Light Utilized by a Short Focus and Long Focus Parabola of Equal Diameters.

The primary function of a headlight is to project illumination to a distance. There are two methods of doing this, in common use: One by passing the light generated through a lens and thus concentrating the rays into a beam; the other by reflecting the light rays by use of a reflector of parabolic shape, which accomplishes the same result. With either equipment, if the light could all originate from a point source (a physical impossibility) located at the focal point of a perfect lens or reflector, the resulting beam would be parallel, and, neglecting atmospheric absorption, would reach to infinity. (See Fig. 1.) However, all light sources have physical dimensions, and hence the beam from such a source used with a projecting lens or reflector will have a certain amount of spread, depending on the size of the light source, the focal length of the projector, etc. (Fig. 2.) Its intensity is assumed to vary inversely as the square of the distance from the projector†.

It is apparent from Fig. 2 that the size of the light source has a very material effect upon the spread of the beam and, therefore, also upon its intensity. For, assuming that we have the same volume of light to work with, it is obvious that if it is spread out over a large area, as with a beam of large dispersion, the light intensity on this area must be lower than if all the light were confined to a small area by projecting it as a narrow beam. Thus, the source of light has great influence on the resultant beam.

The most common light sources used for locomotive headlights are the flame of a kerosene oil lamp, the flame of an acetylene burner, the crater of a carbon arc and the filament of an incandescent lamp. Of these the size of the oil flame is the largest; next to this is the acetylene flame and then comes the arc. With the incandescent lamp, the size of the source depends upon how closely the filament is coiled. Especially on low voltage it is possible to secure a light source of very small dimensions. Assuming that we have a light source of constant area, the greater the volume of light emitted by that source—or, in other words, the higher its candlepower—the greater will be the intensity of the resultant beam.

The flame of the oil lamp is relatively of low intrinsic brilliancy—approximately 9 c.p. per sq. in. Hence, to obtain a large volume of light from this source would require a very large flame, and with a large flame as a light source for a headlight the spread would be too great to obtain a powerful beam. Oil headlights in common service today have beam candlepowers in the neighborhood of 2,500. The oil lamp, therefore, is practically eliminated from the possibilities of producing a beam of sufficient intensity to "pick up" a dark object at a distance of 1,000 feet. The acetylene flame is of considerably higher brilliancy.

There are two electrical means of meeting the requirements: the tungsten filament of a gas-filled lamp, operating at about 1,200 c.p. per sq. in., and the crater of the carbon arc, operating at about 84,000 c.p. per sq. in. Headlights of both types are available, giving beam candlepowers up to 1,000,000. Either of these sources will produce sufficient light in a small enough space to be used to good advantage for powerful headlight service.

Having a certain light source to work with, the resultant beam when this source is used in a projector, will also depend somewhat upon the size and design of the lens or reflector used, and also the accuracy with which the light source is located at the exact focal point. In general it might be said that a glass lens or a glass mirror can be ground and polished more accurately than a metal mirror can be spun; hence, where extremely powerful beams are required, such as in navy searchlights; or where a little "spill" or stray light is objectionable, such as in stereopticon work, the glass lens or mirror is usually used. For headlight service, however, neither extremely powerful beams nor ones with no stray light are desirable. In fact, some stray light striking the immediate foreground is highly desirable, enabling the reading of mile posts, whistle signs, etc. For this reason metal reflectors are most common in railroad headlight service. These may be made of polished aluminum, having a reflection coefficient of about 61 per cent; or of brass, nickel plated, with a reflection coefficient of about 54 per cent; or of brass, silver plated, producing a surface with 86 per cent reflection. The aluminum reflectors have the advantage that they can be buffed up an indefinite number of times, whereas the plating on others gradually wears off with frequent polishing. Replating, however, is not a very serious problem, and many silver plated reflectors are in service. The reason for the nickel surface is that it does not corrode or tarnish quite so rapidly as silver.

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*Railway Electrical Engineer, July, 1916, page 440.

†See Transactions of Illuminating Engineering Society, Vol. X, No. 1, 1915, p. 38: "New Developments in the Projection of Light."

Headlight reflectors are parabolic in shape, but vary as to depth and focal length. With a given diameter a short focus parabola (Fig. 3,*A*) will utilize more of the total light flux from a source than a long focus parabola (Fig. 3,*B*).

A description of most reflectors in common locomotive headlight service, including dimensions and photos of the complete headlight, may be found in Circular N, 1913-14, report of the committee on Locomotive Headlights, American Railway Master Mechanics' Association. This report also contains a very complete treatise of the whole headlight situation as it was at that time, and gives in detail tests conducted on the different types of headlights then on the market.

From Fig. 3 it can be seen that a parabolic reflector of short focus is desirable on account of the high percentage of the light flux it will utilize. Where incandescent lamps are used as a light source, care must be taken not to use so short a focus reflector that the lamp bulb will strike the reflector and prevent the filament coming into focus. As focus-type incandescent lamps are generally made in round bulbs with the filament in the center of the bulb, we can state that the focal length of the reflector should not be less than half the diameter of the lamp bulb plus a small clearance space of, say, ¼ in.

Mention was made above of the importance of actually locating the light source at the focal point of the reflector. It is equally important to retain it at this point, and therein the incandescent lamp is of great advantage. Once it is properly set in place it stays there without further attention, until the lamp fails. When a new lamp is inserted it should be focused, as it is impractical to make all lamps, even of the same type, exactly true. Another advantage of the incandescent light source is that it is absolutely steady, and, furthermore, the headlight (except for very high wattage lamps) can be made dust and moisture proof, thus reducing reflector tarnish to a minimum. The question of how powerful a beam is necessary to "pick up" a dark object the size of a man at 1,000 ft. is one which depends upon several factors; such, for example, as the color of the object, the contrast between the object and its surroundings, the atmospheric conditions, the quality of the headlight beam, etc. As some people see better than others, any observations should be made by several individuals, and precautions taken to insure the approximate representation of average visual power.

It is a curious fact that the quality or color of the beam has considerable to do with the effective pick-up distance. In tests conducted by the Railroad Commission of Wisconsin and reported at the October, 1912, meeting of the Western Railway Club; in tests conducted by the Southern Pacific and reported in the Journal of Electricity, Power & Gas for February 7, 1914, and also in tests conducted by the committee on Locomotive Headlights for the American Railway Master Mechanics' Association, reported in Circular N, 1913-14, it was found that for some reason or other it required a considerably higher beam candlepower where an arc headlight was used than with an incandescent headlight, to pick up a man at the same distance. A curve showing this difference was worked out for equivalent beam candlepowers and reported by the last committee in its circular W, 1914-15.

From data that the writer has been able to collect regarding the Mazda lamp, it would appear that it is necessary to throw an intensity of from .05 to .1 foot-candles on a man in dark clothes, to render him visible at 1,000 ft. on the average railroad track. Formulas and curves for the beam candlepowers necessary, of both arc and incandescent headlights, to pick up men dressed in light, medium and dark clothes have been worked out and reported in a paper entitled "The Locomotive Headlight," given in the Transactions of the Illuminating Engineering Society, Vol. IX, No. 9, 1914, page 909.

It was previously mentioned that the light intensity from a headlight varies inversely as the square of the distance; therefore, taking the writer's maximum figure of .1 foot-candle, the beam candlepower of a projector which would deliver this intensity at 1,000 ft. would be .1 F.C. $\times$ $(1,000)^2$ or 100,000. A beam candlepower of this value is very easy to obtain with an incandescent lamp. There are 6-volt 36-watt incandescent headlight lamps, which will more than accomplish this result*. These are available in 36, 72 and 108 watt sizes, as shown in Fig. 4. The last size is the standard headlight lamp at present used on the Southern Pacific. There are also available 30-34 volt incandescent headlights of 100, 150, 250 and 750 watt capacities, Fig. 4. Due, however, to the higher voltage of these lamps, their filaments are necessarily of finer wire and longer than those of the 6-volt type and, therefore, cannot be concentrated into so small a volume. This necessitates using a higher wattage lamp to obtain the same beam candlepower that is required with the 6-volt type. Many of the 30-34 volt lamps are, however, in service. The beam from the 30-34 volt lamps will also have considerably greater spread than that of the 6-volt lamps. A 150-watt 30-34 volt lamp will be required to equal the beam candlepower of a 36-watt 6-volt lamp.

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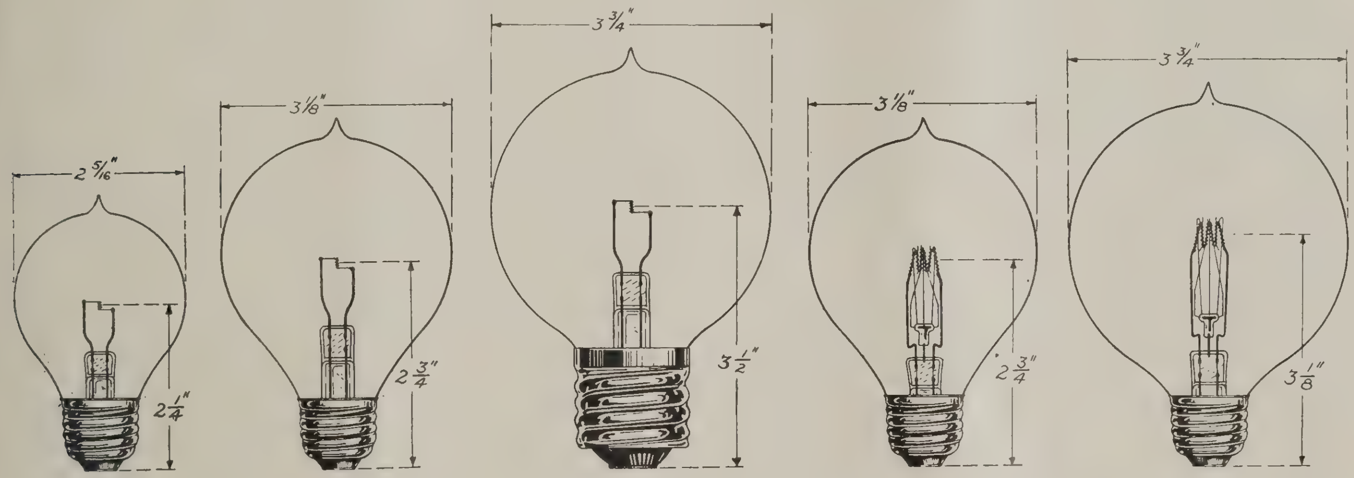
*"Incandescent Headlights and Projectors," I. E. S. Transactions, Vol. X, No. 3, April 30, 1915, p. 271. The beam candlepower here given is maximum and not average across the beam. A higher wattage lamp is desirable to bring the average up to the 100,000 value.

For practical purposes, it is desirable that the spread of the beam should be at least sufficient to cover the entire width of the track, as obviously a very narrow beam might possibly have sufficient intensity without illuminating the full width. It is, of course, impracticable to provide light that would take care of all curves. A reasonable test would take into account the intensity over the full width of a single track. The procedure is to set up the headlight and at a distance of not less than 100 ft. from it draw an arc across a diameter of the beam, having the headlight as its center. This arc should be marked off in feet, and foot-candle intensities measured across it at these points, by means of a portable photometer. The values thus obtained, if averaged and multiplied by the square of the distance from the arc to the headlight, will give the average beam candlepower of the headlight, and from the readings the spread can also be worked out. Detailed instructions for making such tests can be found in the Lighting Journal, Vol. 4, No. 1, January, 1916, in an article entitled "Photometric Measurements of Projectors."



36 Watts, 5.5 and 6 Volts — 72 Watts, 5.5 and 6 Volts — 108 Watts, 5.5 and 6 Volts — 100-105 Watts, 30-34 Volts — 250 Watts, 30-34 Volts

Fig. 4—Incandescent Lamps for Headlight Service

As to the source of current supply for headlights, both storage batteries and turbo-generator outfits are on the market. The latter are coming into increased use and are available for both 6 and 30-34 volt systems. The generators are of sufficient capacity to take care of cab and classification lamps in addition to the headlight, if desired. It is probable that where incandescent lamps are used, the 6-volt 108-watt and the 32-volt 250-watt lamps will be the ones most generally adopted, thus allowing an ample factor of safety in meeting the requirements of the law.

On locomotives at present equipped with arc headlights, the simplicity of control and maintenance of the incandescent lamp may make it desirable to replace the arc. In such cases it will not ordinarily be necessary to discard the old headlight, nor will this be necessary in the case of many oil lamps. The arc mechanism or oil lamp can be removed from the casing and the incandescent substituted. There is on the market an adapter, shown in Fig. 5, which can be used for this purpose. It consists of a Mogul socket mounted in such a manner as to be adjustable in three directions, thus allowing of accurate focusing of the lamp. The adapter can be easily screwed or bolted to the bottom of the headlight casing.

Standard incandescent lamps are available of various wattages, and such lamps are interchangeable, enabling a wide range of choice as to beam candlepower.

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The Headlight Question

It seems probable that the recent order of the Interstate Commerce Commission regarding headlights will be attacked in the courts by some of the eastern roads having a dense traffic handled on multiple tracks under block signal protection. The order of the Commission, which was issued in June, requires that each locomotive "shall have a headlight which will enable persons with normal vision in the cab of the locomotive under normal weather conditions to see a dark object the size of a man for a distance of 1,000 ft. or more ahead of the locomotive." (See Daily Railway Age Gazette, June 16, page 1358.)

The petition for the Commission to regulate headlights came from the railway labor brotherhoods. The order sought by them was opposed by the representatives of the railways. It is a circumstance both remarkable and significant that the requirement finally made is that which the Brotherhood of Locomotive Engineers decided at a convention held in May, 1915, to seek, and that even the verbiage of the order is almost the same as that used in the resolution adopted by the brotherhood. The Commission has been charged ever since it was organized with being subservient to the railway labor unions. Its handling of the headlight question will not improve its reputation in this respect. A committee of the American Railway Master Mechanics' Association somewhat over a year ago made exhaustive tests of high-power headlights. This committee was composed of mechanical officers of the Pennsylvania Lines West, the New York Central, the Louisville & Nashville, the Chicago & North Western, the Chicago, Burlington & Quincy, the Baltimore & Ohio and the Boston & Maine. High-power headlights are used on some of these roads but not on others. The committee, nevertheless, reported against their use on multiple track lines handling a dense traffic, and the Master Mechanics' Association accepted its report. The Interstate Commerce Commission seems to have completely ignored the action of the Master Mechanics' Association.

A large part of the railways of the United States have shown their belief in high-power headlights by voluntarily buying and using them, but it does not follow because many railways have done this that their use everywhere should be required. The physical and operating conditions on our railways vary enormously. There is no similarity between the conditions on a single track light-traffic line in a desert in Nevada or Arizona and those on a four or a six track line in New York or Pennsylvania handling a traffic perhaps 30 or 40 times as dense. Because of these differences in conditions a requirement for headlights applying uniformly throughout the country is absurd on its face. In the second place, the phraseology of the Commission's order is wholly indefinite. What is "normal vision"? What are "normal weather conditions"? What is "a dark object"? A man in a black suit is obviously "a dark object the size of a man." Plainly also, a man in a white suit is not. But how about a man in a gray suit? Are weather conditions normal both when there is bright moonlight and when there is no moonlight? When it has been determined, if it ever shall be, what are "normal vision," "normal weather conditions" and "a dark object the size of a man" it will still be a question as to exactly what kind of a headlight will meet the requirement.

Probably the Interstate Commerce Commission ought to adopt some form of regulation for headlights, but its requirements ought to recognize varying conditions, they ought to be clear and definite, and they ought not to ignore the results of the investigations of the leading railway mechanical experts of the country. The Commission in dealing with questions of safety will always have to rely, to a considerable extent, on the judgment of its subordinate boards, and it is extremely unfortunate that its boards which have to do with such matters have been constituted so largely of men whose point of view is that of the railway labor brotherhoods'. The point of view of the labor brotherhood is not necessarily either that of the mechanical expert or that of the public.—*Railway Age Gazette.*

What Regenerative Braking Really Is

By A. J. Manson

DURING the past few months reference has been made many times in the railroad world to regeneration as applied to electric locomotives. It has been a much talked of subject in both the electrical and railroad fields, due to the fact that this feature is embodied in the electric locomotives operating on the Norfolk & Western over the Bluefield-Vivian division, and also in the locomotives used on the new Chicago, Milwaukee & St. Paul electrification. Before describing the details of regeneration and how it is accomplished, and in order better to appreciate what it means, a short description of the operating conditions on the Norfolk & Western may not be amiss.

The Norfolk & Western

The profile of the electrified portion of the road is shown by Fig. 1. Commencing at East Vivian for 5½ miles the average grade is .7 of 1 per cent; for the next 5¼ miles, the average grade is 1.13 per cent with a maximum of 1½ per cent; for the next 4 miles, the average grade is 1.66 with a maximum of 2 per cent, the highest point of the line being at Coaldale and the heaviest grade through the Elkhorn tunnel. From the tunnel to Bluefield the grade is much less with the exception of a short grade just outside of Bluefield where the average is 1.18 per cent for approximately 3 miles.

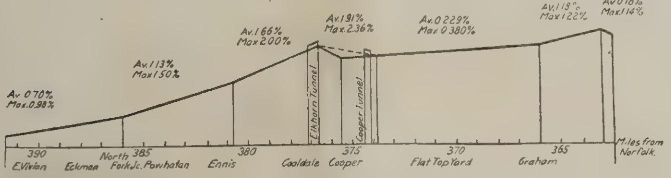

Fig. 1—Profile of the Norfolk & Western Electrified Division

The freight handled is practically all coal, collected from the large number of coal mines in the vicinity of Vivian and between that point and Columbus; so that the load is practically all one way against the grade, and therefore extremely heavy drafts of power are required from the power-house. The trains are made up on an average of 45 cars, totaling 3,250 tons, exclusive of the locomotive. The empties are made up into long trains so that when descending the grade from Coaldale considerable experience and skill are necessary to take them down safely and intact, with the use of air-brakes.

Available Energy on Grades

Considerable energy is available (expressed in foot-pounds or horsepower) on the down grade. For instance, with the 3,250-ton train down the 2.36 per cent grade between Coaldale and Cooper, the horsepower available can be calculated as follows: For each 1 per cent grade, the downpull along the grade is 20 lb. per ton (law of physics), so that on the 2.36 per cent grade there will be 47.2 lb. per ton minus the friction of the train, which we will assume as 7 lb. per ton. There is then a net amount of 40.2 lb. per ton, which, with a 3,520-ton train, made up of 3,250 tons trailing load and a 270-ton locomotive, gives 141,504 lb. The speed in feet per minute at 14 miles per hour is 1,232, so that the horsepower which is to be dissipated at the brakeshoes as heat or which is available for regeneration, is:

$$141{,}504 \times 1{,}232 \div 33{,}000 = 5{,}285 \text{ horsepower.}$$

Regeneration

Regeneration is then the taking of the energy or power available on account of the train descending a grade and which nominally is dissipated as heat at the brakeshoes, and returning this power to the electrical conductor as electrical energy which helps to supply power to some other train operating against a grade, thus requiring less power from the main power station than would be required without regeneration. Returning electric power to the conductor or line, as we term it, means that electric power is actually generated on the locomotive and the horsepower developed on the down grade is converted into watts.

If electric power is shut off from the overhead wire the locomotive is, for the time being, turned into a moving generating station. The generation of electricity goes on whether the turning of the wheels is effected by an outside steam engine, as at the powerhouse, by the movement of a turbine, or by the drivers being turned by the engine and train rolling down the grade, but in any case this turning of the wheels requires the application of some form of force.

The term "watt" is the electrical unit, and 746 of these watts equal one horsepower. We know that power is required to generate electricity and that for every 746 watts one horsepower is required if the efficiency of the machine is disregarded, so that the greater the electrical energy, the greater the horsepower required. We have seen that regeneration is the converting of the energy of the train descending the grade represented by horsepower into electrical power or watts, so that by providing a method for controlling the amount of electrical power returned, this electrical power can be kept constant or can be varied to suit the grade which the train is descending. The amount of energy or horsepower available for regeneration (within limits) is such that the speed of the train down the grade is under perfect control without the use of the air-brakes, they being held in reserve for emergency and for stopping of the train.

Three Phase Motors

The logical procedure is to make use of the electric motors, which normally supply the motive power for the propulsion of the train, for generating the electric current to be put into the line, and this is exactly what is done. The motors are connected to the locomotive axles by gearing, side rods, or a combination of both, so that these motors revolve at all times with the revolution of the drivers. Just how the motors are turned into generators, and how it is possible to return power to the overhead line, and what takes place in the motor, are extremely interesting matters. Take, for example, the Norfolk & Western locomotives, which are of the split-phase type. With these locomotives, advantage is taken of the 2.36 per cent grade from Coaldale to Cooper, and at this point the pusher locomotive, which has been behind the 3,250-ton train while running up the grade from Vivian, is cut off and the train is handled down the grade and from this point east with one locomotive. Moreover, the whole train is handled down this grade by regeneration. The simplicity of the control and the ease with which the train changes from running to regeneration and again at the bottom of the grade from regeneration to running is remarkable and it is all the more wonderful when one realizes that this cycle of operation takes place with the least possible shock to the train and to the rear end.

Referring to the profile, it will be seen that there is a considerable change in grade at Coaldale—a change from 1½ per cent up to over 2.3 per cent down. As the train comes over the top of the hill and a few cars have passed beyond the crest, the engineman shuts off the master controller, changes over to the regeneration position by a simple movement of a handle and then by bringing the master controller on again the locomotive begins to regenerate and picks up car by car as each comes over the crown and begins to descend the 2.3 per cent grade. The change is equally simple at the bottom of the grade when the locomotive reaches the dip, and after a few cars have passed the under-dip the master controller is again thrown off, the locomotive changed back to the running position and the master controller is again thrown on, the locomotive picking up the train; the slack is pulled out a car at a time so that no shock is experienced at the rear end. All of these operations are done with the train maintaining a speed of approximately 14 miles an hour.

In order to understand what is happening, it may be well to consider the fundamental principles of the electric motor. Although, in general, regeneration is the same for all systems in that it provides a means for retardation of the train and for returning of power to the overhead line, still there is some difference, and the subject should be considered under two heads. These are discussed therefore separately and the first concerns regeneration with direct current and single-phase series variable speed motors, while the second concerns the three-phase or constant speed motors.

Regeneration with Series Motors

In dealing with direct-current and single-phase series motors, we may say that the motors used on these two systems are of the series-commutating type, this type of motor having the proper characteristics for general railway work. The series motor gets its name from the arrangement of connections between the armature and the field, these two parts of the motor being connected in series, so that the same current which flows through the armature also passes through the field coils. The connections are shown by Fig. 2A. Since the same current passes through both the field and the armature, the strength of the field varies with the armature or load current, which affects both the speed and the torque of the motor. This torque is represented by the product of the field strength multiplied by the current flowing through the armature, so that the pull increases rapidly with the increase in current which results when the speed is decreased.

In order to regenerate on either of these two systems, the voltage generated by the motors (which is analogous to pressure in a water pipe) must be greater than the voltage or pressure on the electrical conductor, and this pressure generated must be under control. The conditions to be met are similar to the case of a water pipe under, say, 100 lb. pressure. In order to force water into this pipe at 100 lb. pressure, a greater pressure must be used to overcome the pressure in the pipe. The motors must therefore become, for the time being, electric generators. Generators are based upon the discovery by Faraday, in 1831, that an electric current and voltage are generated in conductors by moving them in a magnetic field. Moving the conductor in a magnetic field causes the conductor to cut what is known as "lines of force" and the voltage obtained depends upon the number of these lines of force cut in a given time. It is seen then that the stronger the field—that is, the more the lines of force—the higher will be the voltage at the same rate of cutting, or with the same lines of force if the rate of cutting be increased the voltage will also be greater. This point is here referred to to make clear the arrangement followed on these systems of regeneration.

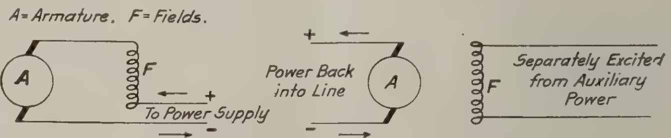

Fig. 2—Simple Wiring Diagram of a Direct Current Series Motor and a Direct Current Shunt Generator

Connections

In the case of the motors, the armatures are driven by gearing or side-rods or both, and we have a magnetic field which can be produced by current flowing through the field coils mounted on the pole pieces. It is then only a question of combining and controlling these features to obtain a generator. It would be impossible to regenerate with the armature and field of the motor connected in series, as this is the connection for a series generator, and the operation of a series generator on a constant potential circuit is a problem which has not yet been successfully solved. The change in connections is shown by Fig. 2B, the field being disconnected from the armature and separately excited from some auxiliary power. Instead of the series generator, we now have a shunt generator, and by adjusting the amount of current flowing through the separately excited field which determines the strength of the field with its lines of force, sufficient voltage can be generated in the armature (A) to force currents back into the line against the line voltage.

The connections and arrangement of circuits differ in the case of the direct current and alternating current locomotives suitable for regeneration so that each system will be considered separately.

Direct Current Motors

In direct current operation the field can be excited from a separate source of power such as a storage battery, but better, from a motor-generator set. The motor-generator set would probably consist of two machines coupled together, one of which is a motor and the other a generator. The motor would be connected to the line voltage, or, as we would say, the trolley wire, and would run probably all the time either with the locomotive hauling or regenerating. The generator would supply the proper amount of current for exciting the field of the motors when in the regenerating position. If four or more motors are mounted on the locomotives, a wide variation of speed during regeneration can be obtained by combining the motors in the parallel and series combination. During acceleration of the locomotive the motors are operated in combination, starting, say, in the case of the four-motor equipment, with the four motors in series, then transferring to two motors in parallel, and two of these parallel sets in series, and finally, to the four motors in parallel. Three running speeds are thus possible with these combinations, say, 8 miles an hour with the four motors in series, 16 miles an hour with the second arrangement, and 32 miles an hour with the four motors in parallel. These combinations work equally well in the reverse direction when regenerating.

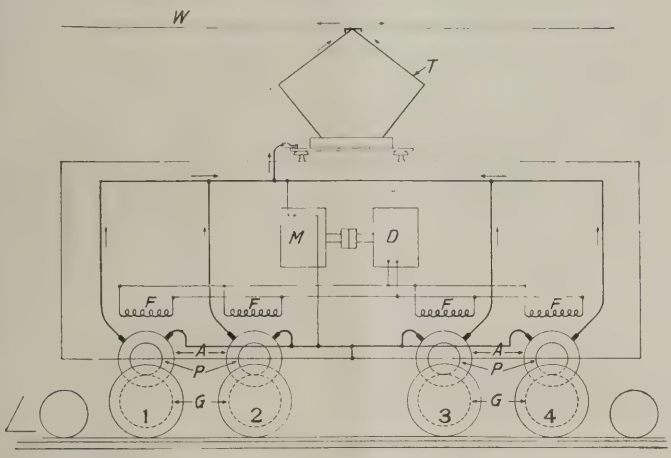

Fig. 3—Simple Diagram of Connections for Direct Current Regeneration with a 4-Motor Locomotive

At the highest speed, say, 32 miles an hour, if regeneration is commenced, the motors will be used as four in parallel, and as the train speed decreases, at a speed as outlined below, the combination would be changed over into two in parallel and two sets in series, and with the further reduction of speed, the motors would be connected four in series. The reason for changing the combination is apparent from the following: As the train is reducing in speed the control must be such that more current is passed through the fields of the motors which are generating so as to keep the voltage up above the line voltage. As a certain number of lines of force must be cut during a certain time to give the voltage necessary, and since the reduction in speed cuts down the rate, it is necessary to increase the number of these lines of force so that the total number of lines cut will remain the same. Of course, there is a limit to the lowest speed below which point it is not possible to keep up the field strength, hence the voltage would decrease below the line voltage and regeneration would stop unless the motors were put into the second combination. With the second combination we have two motors in series, the voltage of each motor being added together to force current against the line voltage. In the last arrangement (four motors in series), there are four motors whose voltages are added together to oppose the line voltage. The operation of the motors connected in series to give the proper voltage is analogous to a double-acting pump or compressor where the air pressure or water pressure obtained from the first piston passes into a high pressure cylinder, where it is increased to a much higher pressure by the movement of the second piston. It is not possible to carry this regeneration down to zero speed and air-brakes are required to complete the stop.

Electric Braking on the St. Paul

The electric locomotives recently built for the Chicago, Milwaukee & St. Paul are direct-current locomotives suitable for regeneration. These locomotives have an arrangement similar to that outlined above, using a motor-generator set to separately excite the fields; with these locomotives regeneration is obtained from 25 miles an hour to 7 miles an hour, at which speed brakes must be applied to bring the train to a stop.

Fig. 3 shows the diagrammatic view of connections for the d.c. regeneration. This diagram shows a 4-motor locomotive of the geared type; the gears are represented by *G,* pinions by *P,* and armatures by *A.* The motor-generator set is represented by *M* for the motor and *D* for the generator, and it may be noted that the current from the generator is fed to each of the fields of the motors represented by *F.* The arrows indicate the direction in the flow of the current generated by the motors which passes up through the trolley and hence to the overhead wire *W.* It should be understood that these circuits are all made or broken by switches and the arrangement is such that they are under perfect control of the engineman so as to enable him properly to handle regeneration under different speeds and on different grades, as explained above.

Regeneration must not be confused with what is known as "dynamic braking"—with direct-current equipments of small sizes. If two series motors with fields reversed are connected together on themselves, either directly or through resistance, one of these motors will pick up as a generator, the other as a motor running backwards, and the car will be brought to a standstill. The voltages generated in this way are very low, since the resistance of the circuits is very low and, moreover, the current circulates between these two motors and does not in any way return to the power supply, as with this arrangement there are no connections to the line or trolley wire. With regeneration proper the energy of the moving train which would otherwise cause it to "run away" on a steep down grade is changed into electric energy and given back to the overhead wire and to the power-house. It is new energy developed by the moving train going down hill.

The principles involved in regeneration with three-phase alternating-current locomotives will be discussed in a future article.

Locomotive Crane Trolley

One of the largest alternating current cranes ever installed for handling locomotives has been furnished recently by the Whiting Foundry Equipment Company, Harvey, Ill., to the Seaboard Air Line for the new shops at Portsmouth, Va. The crane is of 160 tons capacity with two 80-ton trolleys, one of which is equipped with a 10-ton auxiliary hoist.

Templets for Machine Foundations

WHEN constructing foundations for electrical and all other machinery which requires anchor bolts, templets should be made whereby the bolts can accurately be located in the foundation. These templets are ordinarily constructed of ⅞ in. clear grained white pine stock, 4 in. to 6 in. wide. Yellow pine can be used instead, and it makes a good, though heavy templet. Templets of structural steel sections have been used in certain cases where the same templet is applied over and over again, but their cost is too great to permit their use for ordinary foundation work. Some relatively simple templets, which will indicate how more complicated ones can be made, are illustrated and described in the following paragraphs:

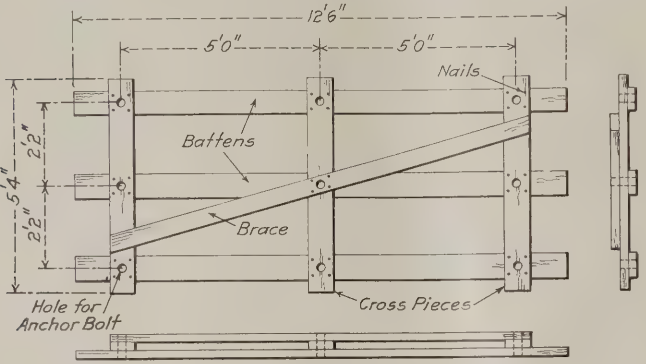

Fig. 1—A Nine-Bolt Templet.

A 9-bolt templet for an electric motor or generator is shown in Fig. 1. The stock from which this is made is ⅞ in. x 4 in. yellow pine, and a hole is bored through the templet for each anchor bolt. Each strip of the templet is made somewhat longer than would be necessary, merely to carry the bolts. This extra length is provided in each case so that the templet can be securely supported. The extending ends, when the templet is in position over the foundation, rest on battens prepared for the purpose, or on the form, if the foundation is to be of concrete and a form is required.

A 6-bolt templet for a self-contained generating unit is shown in Fig. 2. The holes through the templet for the anchor bolts should be from 1/32 in. to 1/16 in. larger in diameter than the bolts that they are to accommodate, to provide for clearance and for the unavoidable warping of the wood. The three cross pieces are of ⅞ in. x 6 in. stock and are 6 ft. 0 in. long. The battens are of the same size stock, but are 9 ft. 8 in. long. The lengths of both the cross pieces and the battens were determined by the length and width of the foundation, since both the cross pieces and the battens must extend beyond the foundation and across the supports which are to carry them.

The templet for the anchor bolts of any foundation should be accurately located over the foundation, because its position will, obviously, determine the positions of the foundation bolts in the foundation. The templet should be thus disposed and supported, as will be described below, before the anchor bolts are placed in the templet and before any concrete is poured in the foundation excavation. Usually the templet should be so located that it will (1) lie at some certain elevation, and (2) rest in some certain relation with some other machine, line shaft, or other part of the structure.

Where the machine or prime mover, which will ultimately be located on the foundation, is to be driven from or to be driven by a line shaft, it is obvious that then the templet for the new machine must be located in a definite relation to the line shaft. A similar condition occurs where one machine or device is to be driven by another.

The drawings, which should be furnished for every foundation installation of any consequence, will usually indicate precisely how the templet should be located. Where a transit is available, it should be used in projecting the center lines whereby the location of the templet is fixed. This instrument can also be used as a level for determining the proper elevation of the templet. If no transit is available, satisfactory results may, as a rule, be obtained by using tape line and carpenter's level; but the work can, ordinarily, be done much more rapidly with a transit.

After the installer has determined accurately the center lines and the elevation for the templet by following the procedure suggested above, he should then firmly fasten the templet in this position. Where the foundation is to be of concrete and forms have been provided for it, the templet can usually be nailed to the forms in such a way that it will be restrained from the moving. Where forms have not been provided, the templet can then be supported on stakes driven into the earth at suitable locations. Every precaution should be taken to prevent the shifting of the templet as a whole, or of any part thereof, while the foundation is being constructed. Usually the concrete handlers have little respect for the templet, and hence will often strike it severe blows with the wheelbarrows, or with charges of concrete, which are being dumped into the foundation excavation.

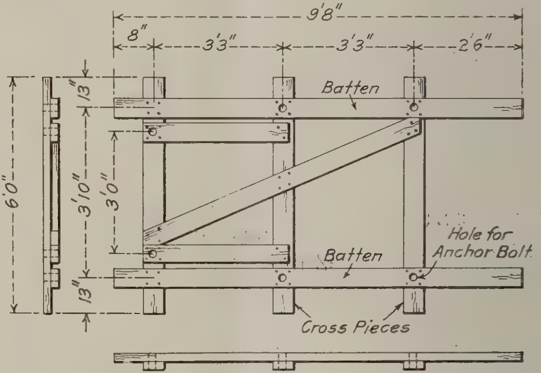

Fig. 2—A Six-Bolt Templet for a Self Contained, Engine-Driven Generating Set.

Where columns or walls are adjacent to the foundation location, it is always advisable to install timber struts or braces from the templet to these members as a precautionary measure. The braces should be firmly nailed to the templet and also tied to the building members with wood or metal yokes or by some similar method.

Calculations in Car Lighting Systems

By W. L. Bliss*

THE following article has been prepared for the purpose of making clear to those interested in electrical problems in general and in car lighting problems in particular, some of the phenomena that occur in connection with the use of generators and storage batteries, due to the varying electromotive forces of such generators and batteries and the varying loads that may be connected to them. In car lighting work especially, some of these phenomena are little understood or appreciated.

We are all familiar with the fact that in a car lighting system the generator comes up to speed and voltage, the automatic switch closes, the generator speed and voltage increase, the battery begins to charge, and the lamps are furnished current from the generator. Then, when the train slows down, all of these actions reverse, and the storage battery is eventually called upon to discharge and light the lamps, whereas just previously it had been receiving a charge. The automatic switch is compelled to open through the reverse action of the current flowing through its coils, and while it is apparent to any observer that these phenomena are the result of certain established conditions, it is not perfectly clear as to just what the relation between the various electro motive forces, currents and resistances happen to be. We are also familiar with the fact that when a storage battery has become fully charged, the generator voltage may be reduced to a point where the storage battery just floats. This phenomenon has become one of great interest and importance in connection with the recent development and extension of the use of the ampere hour meter.

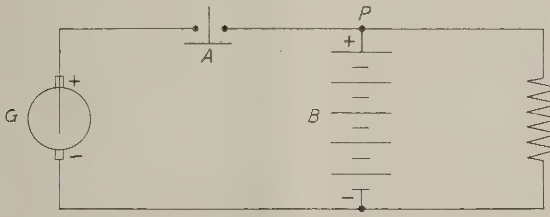

Fig. 1. A Schematic Diagram Representing an Axle Car Lighting System.

This article is intended to explain from a theoretical standpoint why it is that these various phenomena occur and why slight changes in the values of the quantities assumed produce comparatively great variations, both in magnitude and direction, in the resulting current.

Fundamental Principles

The explanation takes the form of an elaboration of Ohm's law and an application of the laws enunciated by Kirschoff. Those who have followed the lessons in elementary algebra will have no difficulty in following and understanding this discussion. The schematic diagram in Fig. 1 represents an axle system of electric car lighting. G is the generator, B the storage battery and L the load. The familiar automatic switch is represented by A, and is supposed to be closed. The load L is composed of lamps, and all circuits connected across the mains such as the generator field circuit, the lifting coil circuit of the automatic switch, the voltage coil of the generator regulator and the voltage coil of the lamp regulator. The lamps, if all were turned on, would, ordinarily, consume many times the current of all the other circuits connected across the mains, and their number and the current they consume may be varied at will. The resistance of certain of the other circuits will vary, such as the resistance of the field circuit of the generator, due to variations in pressure on the carbon pile, etc., but there is always one equivalent resistance for all the circuits in parallel across the mains and this we have represented by the general load L. Each of the three elements, G, B and L, possesses resistance and in addition the generator and battery possess electromotive forces or voltages. Therefore let

E_1 = generator voltage
γ_1 = generator resistance
E_2 = battery voltage
γ_2 = battery resistance
γ_3 = load resistance
C_1 = generator current
C_2 = battery current
C_3 = load current

We may assume that the first five quantities of voltage and resistance are known and that at any moment under consideration they are constant. The problem is to determine the value and sign of the three resulting currents.

Assume that currents flowing around the circuits in a clockwise direction are positive and vice versa. According to Kirschoff's first law the algebraic sum of the currents meeting at any point is zero. Let that point be P. Assume that the generator current C_1 is flowing clockwise and is positive, that the battery current C_2 is flowing clockwise (discharging) and is positive and that the load current C_3 is flowing counter-clockwise and is negative. These currents meet at the point P and their algebraic sum is zero.

This is expressed thus,

$$C_1 + C_2 - C_3 = 0$$

or

$$C_1 + C_2 = C_3 \quad \ldots\ldots\ldots\ldots (1)$$

This gives us one equation.

According to Kirschoff's second law the algebraic sum of the electromotive forces in any circuit is zero. That is to say, the $C\,\gamma$ drops are algebraically equal to the live e.m.f's.

Take the circuit of the generator through the load alone, and we have

$$E_1 = C_1\,\gamma_1 + C_3\,\gamma_3 \quad \ldots\ldots\ldots\ldots (2)$$

which means that the e.m.f. of the generator is just consumed in sending the generator current C_1 through the generator resistance γ_1 and the load current C_3, through the load resistance γ_3.

Similarly taking the circuit through the battery and load alone, we have:

$$E_2 = C_2\,\gamma_2 + C_3\,\gamma_3 \quad \ldots\ldots\ldots\ldots (3)$$

and a similar explanation obtains.

We now have three equations and three unknown quantities C_1, C_2, and C_3, and the solution of these equations will give the values of C_1, C_2, and C_3 in terms of the e.m.f's and resistances of the three circuits.

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The solution is left to the reader for practice. It is simple but somewhat tedious and the results are as follows:

$$C_1 = \frac{E_1\,\gamma_2 + E_1\,\gamma_3 - E_2\,\gamma_3}{\gamma_1\,\gamma_2 + \gamma_1\,\gamma_3 + \gamma_2\,\gamma_3} \quad \ldots\ldots\ldots(4)$$

$$C_2 = \frac{E_2\,\gamma_1 + E_2\,\gamma_3 - E_1\,\gamma_3}{\gamma_1\,\gamma_2 + \gamma_1\,\gamma_3 + \gamma_2\,\gamma_3} \quad \ldots\ldots\ldots(5)$$

$$C_3 = \frac{E_1\,\gamma_2 + E_2\,\gamma_1}{\gamma_1\,\gamma_2 + \gamma_1\,\gamma_3 + \gamma_2\,\gamma_3} \quad \ldots\ldots\ldots(6)$$

It will be observed that each of the above fractions has the same denominator, and that if the numerators of (4), and (5), be added together the sum will equal the numerator of (6), which agrees with equation (1).

It is interesting and instructive to note that, in the case of the load current C_3, the numerator contains no negative sign and therefore no matter what may be the values of E_1 and E_2 and γ_1, γ_2, and γ_3, the numerator will always be positive and therefore the sign of C_3 will never change. This agrees with experience as it is well known that the direction of the current through the load never changes.

The cases of the generator and battery currents are very different. Take the battery current first. The third term of the numerator is negative. Hence if $E_1\,\gamma_3$ which is the product of the generator current and the load resistance is less than $E_2\,\gamma_1 + E_2\,\gamma_3$ the numerator will be positive and the sign of C_2 will be positive and the battery current will flow clockwise or be positive and the battery will be discharging. If, however, $E_1\,\gamma_3$ is greater than $E_2\,\gamma_1 + E_2\,\gamma_3$ the sign of the numerator will be negative, the battery current will be negative and the battery will be charging. This agrees with experience as we know the battery may deliver full current on discharge or receive full current on charge and no check is placed upon the freedom given the battery to change from charge to discharge and vice versa, depending upon the relation of E_1, E_2, γ_1, γ_2 and γ_3. We all know E_1 changes with speed and field strength and E_2 changes with the physico-chemical condition of the battery. There is a slight change in γ_1 as the generator temperature increases but it becomes fairly constant and may be assumed as such. There is a charge in γ_2 as the gravity of the electrolytic varies and as other charges in the cells occur. Changes in γ_3 occur whenever the number of lamps is changed or whenever a charge in resistance of any shunt circuit occurs, such as the field circuit containing a carbon pile rheostat. These are the two and only two conditions that determine whether the battery shall discharge or charge. And lastly if $E_1\,\gamma_3$ is just equal to $E_2\,\gamma_1 + E_2\,\gamma_3$ the numerator is zero, the battery current is zero and the battery floats. This is the only condition that determines whether or not a battery will float across the line.

Consider the generator current C_1. If $E_2\,\gamma_3$ be less than $E_1\,\gamma_2 + E_1\,\gamma_3$ the numerator is positive, the current is positive and the generator is delivering current. If $E_2\,\gamma_3$ is greater than $E_1\,\gamma_2 + E_1\,\gamma_3$ then the numerator is negative, the current is negative and current is flowing back through the generator, driving it as a motor. This last condition is undesirable and a check is put upon it in the form of an automatic switch, that will either prevent any or only a small current to flow negatively through the generator. And as long as equation (4), (5) and (6) remain true, the necessity for an automatic switch or its equivalent in every axle system of electric lighting will exist.

Numerical Examples

A few numerical examples will serve to illustrate the foregoing remarks. Although the values assumed below are all reasonable and may be encountered in practice, it should be remembered that they represent a certain assumed condition and do not necessarily hold true for all conditions. In working out a practical example the proper values of generator voltage, generator resistance, battery voltage, battery resistance, load resistances, etc., must either be determined experimentally, chosen arbitrarily or assumed to suit the conditions in question. It is understood, therefore, that the values of floating generator voltage, the generator voltage required to kick out automatic switch, etc., which are calculated below, are true only for the conditions herewith assumed.

Assume the generator voltage $E_1 = 35$ volts
Assume the generator resistance $\gamma_1 = .1$ ohm
Assume the battery voltage $E_2 = 32$ volts
Assume the battery resistance $\gamma_2 = .05$ ohms
Assume the load resistance $\gamma_3 = .1$ ohm

Substituting these values in equations (4) (5) and (6) we get

$$C_1 = \frac{(35 \times .05) + (35 \times 1) - (32 \times 1)}{(1 \times .05) + (.1 \times 1) + (.05 \times 1)} = 30.6 \text{ amperes}$$

That is, the generator delivers 30.6 amperes.

$$C_2 = \frac{(32 \times .1) + (32 \times 1) - (35 \times 1)}{(1 \times .05) + (.1 \times 1) + (.05 \times 1)} = 1.29 \text{ amperes}$$

That is, the battery is discharging 1.29 amperes.

$$C_3 = \frac{(35 \times .05) + (32 \times .1)}{(.1 \times .05) + (.1 \times 1) + (.05 \times 1)} = 31.9 \text{ amperes}$$

That is, the load is 31.9 amperes.

These results check very closely, for adding the generator and battery currents together we get 31.89, which is the load current. Under these conditions, the generator is carrying the load but not charging the battery. To cause the generator to charge the battery as well as carry the load, a change is necessary that will make the value of C_2 negative. In other words $E_1\,\gamma_3$ must be greater than $E_2\,\gamma_1 + E_2\,\gamma_3$. Suppose the generator is speeded up so that its voltage = 37 volts.

Substituting this new value for E_1 we get

$$C_1 = \frac{(37 \times .05) + (37 \times 1) - (32 \times 1)}{.155} = 44.19 \text{ amperes}$$

$$C_2 = \frac{(32 \times .1) + (32 \times 1) - (37 \times 1)}{.155} = 11.60 \text{ amperes}$$

$$C_3 = \frac{(37 \times .05) + (32 \times .1)}{.155} = 32.59 \text{ amperes}$$

The generator now puts out 44.19 amperes and the battery is being charged with 11.60 amperes and the load is 32.59 amperes. The sum of the charging current and load current is exactly equal to the generator current. Thus, it will be seen that when the generator voltage is increased 2 volts from 35 to 37 to produce a charging current of 11.60 amperes, the load current also increases from 31.9 to 32.59 amperes and since the resistance of the load is 1 ohm the load voltage rises only .69 volt from 31.90 to 32.59. This explains why it is that quite a moderate increase in charging current may be forced into the battery by raising the generator voltage and yet the lamp voltage increases very little.

Battery Floating Conditions

Let us now examine the condition under which the battery will just float. This means that $C_2 = 0$ or that $E_1\gamma_3$ must just equal $E_2\gamma_1 + E_2\gamma_3$. Putting this in the form of an equation we get

$$E_1\gamma_3 = E_2\gamma_1 + E_2\gamma_3$$

Solving for E_1 we get as the critical value for generator voltage,

$$E_1 = \frac{E_2\gamma_1 + E_2\gamma_3}{\gamma_3}$$

This equation is particularly interesting as it is seen that it does not involve γ_2 the battery resistance. Indeed, this is as it should be, for if no current is to flow through the battery, it makes no difference whether the resistance of the battery is zero or infinity and therefore opening and closing a battery switch under floating conditions does not in the least disturb or affect the equilibrium of the system.

Substituting our original values we get

$$E_1 = \frac{(32 \times .1) + (32 \times 1)}{1} = 35.2 \text{ Volts}$$

Therefore, when the generator voltage is 35.2 and the battery voltage 32, the battery current is zero and the battery floats. To prove the battery current is zero substitute for E_1 the value 35.2 in equation (5) and we get

$$C_2 = \frac{(32 \times .1) + (32 \times 1) - (35.2 \times 1)}{.155} = 0$$

Again it is interesting to determine under what conditions the battery will float and at the same time have the voltage of the battery equal to the voltage of the generator. Taking our equation for generator valtage,

$$E_1 = \frac{E_2\gamma_1 + E_2\gamma_3}{\gamma_3}$$

let us make $E_1 = E_2$ by substituting E_2 for E_1, thus,

$$E_2 = \frac{E_2\gamma_1 + E_2\gamma_3}{\gamma_3}$$

dividing by E_2 and transposing we get

$$\frac{\gamma_1 + \gamma_3}{\gamma_3} = 1$$

The left hand member of this equation can equal unity under either of two conditions; first when $\gamma_1 = 0$ or second when γ_3 is very great compared with γ_1. This means that the resistance of the generator must be zero or very small indeed, or the load resistance must be infinite or very high, for the battery to float with its voltage just equal to that of the generator. It might be asked: Will not the battery float when its voltage is exactly equal to that of the generator? The answer is Yes, provided there are no other circuits across the line requiring current. If $\gamma_3 = \propto$, no current will be consumed by the load. Such a condition would be represented by the diagram in Fig. 2, the load having been removed. By the application of Ohm's law we have

$$C_1 = \frac{E_1 + E_2}{\gamma_1 + \gamma_2} = C_2$$

because C_1 and C_2 are equal. It is quite evident that if $E_1 = E_2$, C_1 will be zero. But as soon as a resistance or circuit is connected across the mains, the generator must supply it with current and to do so the generator voltage must be increased slightly. Taking the equation of floating condition

$$E_1\gamma_3 = E_2\gamma_1 + E_2\gamma_3$$

let us solve for $\gamma_3 = \dfrac{E_2\gamma_1}{E_1 - E_2}$

This may be called the critical load or floating load. The denominator of the right hand member is the difference between the generator and battery voltages. It is seen that if $E_2 = E_1$ this denominator becomes zero and the value of γ_3 becomes infinite. This agrees with our previous statement, viz.: that if the battery is to float with its voltage equal to that of the generator there can be no load whatever.

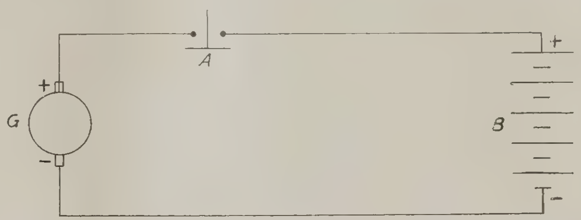


Fig. 2. A Schematic Diagram of an Axle Car Lighting System with the Load or Lamp Circuit Removed. This Is a Condition Where the Load Resistance Equals Infinity and Is the Only Condition Where the Battery Will Float When Its Voltage Is Exactly Equal to That of the Generator.

Assume that $E_1 = 35.2$ $E_2 = 32$ $\gamma_1 = .1$

What is the critical load that must be connected across the mains to make the battery float?

$$\gamma_3 = \frac{32 \times .1}{35.2 - 32} = \frac{3.2}{3.2} = 1 \text{ ohm.}$$

One ohm will be the exact value of this critical resistance. Suppose the voltage of the battery had been 33 instead of 32, then

$$\gamma_3 = \frac{33 \times .1}{35.2 - 33} = \frac{3.3}{2.2} = 1.5 \text{ ohms.}$$

Suppose the voltage of the battery was very close to that of the generator, say 35.1, then

$$\gamma_3 = \frac{35.1 \times .1}{35.2 - 35.1} = \frac{3.51}{.1} = 35 \text{ ohms.}$$

Suppose battery voltage exactly equal to generator voltage, then

$$\gamma_3 = \frac{35.2 \times .1}{35.2 - 35.2} = \frac{3.52}{0} = \propto \text{ as before.}$$

Lastly let us examine the condition that requires the automatic switch to open. To what value must the generator voltage be reduced so that 5 amperes discharge through the switch will take place and open it, assuming that 5 amperes reverse current will do this?

Taking equation (4) for generator current solve for E_1 as follows:

$$E_1 = \frac{C_1 (\gamma_1 \gamma_2 + \gamma_1 \gamma_3 + \gamma_2 \gamma_3) + E_2 \gamma_3}{\gamma_2 + \gamma_3}$$

$$= \frac{(C_1 \times .155) + E_2 \gamma_3}{\gamma_2 + \gamma_3}$$

Now make $C_1 = -5$ amperes and substitute original values and we get

$$E_1 = \frac{(-5 \times .155) + (32 \times 1)}{.05 \times 1} = 29.74 \text{ volts.}$$

That is, when the generator voltage drops to 29.74 volts, 5 amperes will flow backward through the generator and open the switch.

The battery discharge current will be

$$C_3 = \frac{(32 \times .1) + (32 \times 1) - (29.74 \times 1)}{.155} = 35.22 \text{ amperes}$$

The load current will be from equation (1)

$$C_3 = -5 + 35.22 = 30.22 \text{ amperes.}$$

These illustrations might be endlessly extended, and it is suggested to the reader that he assume his own values for E_1, E_2, γ_1, γ_2 and γ_3 and determine the resulting values for C_1, C_2 and C_3, always keeping in mind the necessity for choosing reasonable and possible values.

The subject may be elaborated to any degree by splitting the load circuit into its components and for each circuit added another equation similar to either (1), (2) or (3) must be established and solved in order to get the value of C_4 and additional currents.

High-Power Incandescent Headlight

On the electrified division of the Chicago, Milwaukee & St. Paul Railway the line traverses states whose statutes require an illuminant of 1,500 unreflected candlepower for all locomotive headlights. This has made imperative the construction of a headlight for the electric locomotive which would accommodate a pendant-mounted 34-volt, 750-watt, focus-type, Mazda C lamp. Such a large headlight made necessary a rolled-up steel casing with a spot-welded back, classification number boxes projecting at angles of approximately 30 deg. being provided on both sides. Metal stencils stamped with the number of each locomotive, backed with opal suffusing glass and fronted with clear glass are carried in the number box doors, the numbers being illuminated by direct light from the lamp passing through slots in the reflector. The headlights are equipped with a ball-and-socket focusing mechanism and a solid case iron base, and they have 20-in., parabolic, silvered-metal reflectors.

The heat radiated from the extremely high-powered lamp calls for special attention to ventilation and involves the use of a door pane of solid, heat-resisting glass, which will also withstand the severe mechanical shocks and the impact of birds which, becoming blinded by the intense light, fly against the glass like moths toward a flame. This headlight, when equipped with the 34-volt, 1,500-c.p. lamp, will give approximately 1,150,000 beam candlepower. It is, without question, the most powerful incandescent headlight in commercial operation today. Practically all of the apparent candlepower is exerted within an arc extending 5 deg. from the center of the beam, the maximum approximating 250,000 c.p., being distributed within 1 deg. from the center of beam.

The current supply for the lamp is taken from slip rings on a 9-kw. control generator at 96 volts. It is then transformed to 34 volts, and a tap is provided on the transformer secondary to give one-half the voltage for dimming purposes.—*Electric Railway Journal.*

Lignite as a Fuel in an electric station has given highly economical results, according to Engineering of June 30. At the Weiswiller station, near Acken, Germany, lignite of about 2700 b.t.u. per pound, and with 64 per cent moisture is burned directly on the boiler grates. About 4 kg. or 8.8 lb. of lignite are used per kilowatt-hour generated. Ten tons of lignite are valued at 10.85 marks so that the fuel cost on this basis works out at about 0.1 cent per kilowatt-hour. Other charges amount to 0.135 cent per kilowatt-hour, making the cost of electric energy roughly 0.2 cent per kilowatt-hour.—*Iron Age.*

The Alloys in a Zeppelin.—A French chemical journal has published an analysis of the alloys used in the construction of a Zeppelin brought down in France. For the angle brackets it was found that aluminum entered into the composition to the extent of 90.27 per cent with 7.8 per cent of zinc, 0.73 per cent of copper, and small amounts of iron, silicon, manganese and tin. For the channel sections an alloy composed of 88.68 per cent of aluminum, 9.1 of zinc, and about the same quantities of the other elements as for the angle brackets was used. The braces were evidently of commercial aluminum.

The Transport of Heavy Guns.—With the size and weight of naval guns railways are only interested in so far as they have to carry them from the factory to the ship. This they are seldom called upon to do, but as the war on land is fast becoming a series of sieges in which the heaviest ordnance is used, this transport from place to place in warfare becomes a vital question. Not only have these huge guns to be shifted along the front, but they have to be moved backward and forward with the line of battle. If the light railways and their rolling stock, which do such good service at and near the front, could possibly be adapted for the purpose nothing more would be required. This is a counsel of perfection and the problem is, it is to be hoped, engaging the attention of all railway engineers. It is a problem that will require to be constantly solved until all the fighting is transferred from the land to the air. Were provision made for carrying these heavy loads on the normal or standard gages it should not be difficult to devise a means of transporting the broad-gage trucks on the narrow and lighter gages—as, indeed, is already done on several lines—and the less shifting these unwieldy monsters would have to undergo the quicker would be the process of bringing them to the places where their destructive power would be most effective.—*Railway Gazette, London.*

Flashing in Railway Motors and Generators

By Gordon Fox

A FLASHOVER or buckover in any direct current machine may be defined as the formation of an arc of vaporized metal between points of differing potential. Flashes may originate from many causes. In all cases, however, the presence of the vapor is necessary to form the conducting arc. After the arc is once established between points of sufficiently differing potential it is quite easy for the dynamic current to flow across the low resistance path thus afforded. Whatever sets up the initial arcing sufficient to vaporize the copper is the basic cause of the flashover. The tendency for the small arc to spread is influenced by the surrounding potential gradient—that is, the voltage per unit of distance between adjacent commutator bars or other live parts. Having thus defined flashing in a broad way, we will consider it, first, in connection with motors, then as applied to generators.

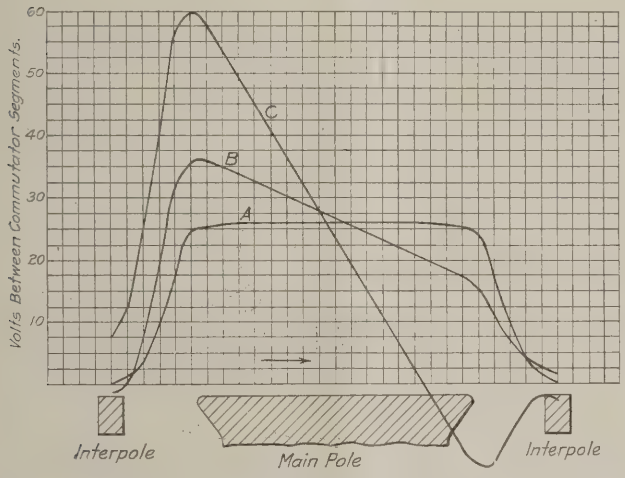


Fig. 1—Field Form Curves for a Railway Motor with Solid Poles. Curve A—No Load, Curve B—Full Load, Curve C—Field Form After Current Has Been Interrupted and is Being Suddenly Reestablished.

Flashing in Motors

Since a flashover requires, first of all, an initial vaporizing spark at the brushes, it follows that good commutation is a first requirement. Consequently interpoles have been used and continue to be used to relieve this tendency. The influence of interpoles is not as beneficial when applied to railway motors, as in the case with other types. This is due partially to the fact that the load is irregular. For steady running, even with overloads, the interpole motor has proved superior to the non-interpole machine. In some other respects little gain is made.

Armature Reaction

The flux distribution under the main poles of a motor is influenced by armature reaction. The tendency is to crowd the magnetic lines against the rotation to one side of the pole face. The flux distribution due to the main field ampere turns and the field form as modified by the magnetizing influence of full load armature current are shown in Fig. 1. The flux distribution controls the voltages between commutator segments connected to coils in different locations under the field pole. Non-uniform flux means correspondingly uneven distribution of the voltage between brush studs. In any direct current machine the sum of the individual voltages between segments over a brush span equals the full voltage. But the voltage between any two adjacent segments depends upon the strength of the field in which the connected coils lie. It is evident that the more the flux is crowded to one side of the field pole, the more peaked is the field form and the higher the maximum voltage between segments. The higher this voltage the easier it is for any initial arcing to spread because of the steep potential gradient along the commutator surface next to the trailing edge of the brushes. Hence, strong armature reaction encourages both sparking and flashing. The function of the interpole is to neutralize armature reaction in the zone in which are located the commutated coils. Outside of this zone the interpole has little influence. The interpole improves matters by lessening the tendency for the initial sparking, but does not prevent the growth of an arc, once started, into a complete flash over.

Irregularity of Load

The irregularity of load is responsible for much of the trouble with both interpole and non-interpole machines. It was shown that armature reaction has a detrimental influence. The degree of armature reaction depends upon the relative armature and field magnetizing forces. Irregularity of load contributes to excessive armature reaction for short periods. The power supply may be momentarily interrupted, as frequently occurs in railway service, on account of section breaks in the trolley, breaks in third rails, rapid operation of the controller or other causes. When the power is suddenly re-established the armature current builds up instantly and the resulting cross flux also builds up quickly since the magnetic circuit is laminated iron and air. The main field flux and the interpole flux build up less rapidly since the solid metal of the frame introduces greater hysteric lag. This means that, for an instant, the interpole is not very effective. Since the field flux is low the counter voltage remains low until the field builds up to a value to increase the counter voltage to correspond to the increased line voltage. During the interval, while the counter voltage is building up, the armature current is abnormally high and the armature is strong relatively to the main field and the field form is very peaked. Curve C, Fig. 1, shows the flux distribution under this temporary severe condition. Any sparking started at the brushes may now be easily carried across the commutator segments. It would be impractical to laminate the entire field frame for mechanical reasons. It is, therefore, unavoidable that the field magnetism builds up less rapidly than that of the armature.

Rapid Change in Field Flux

Rapid change in the value of the field flux is not entirely desirable. The reason will be understood by reference to Fig. 2. This illustrates the fact that, although the coils midway between poles do not cut many magnetic lines, they do link them. So long as the magnetic flux is steady there is no resulting action, but if the flux interlinking a coil be changed, a voltage is induced in the coil. It will be seen that during sudden load changes in a series motor there is an induced voltage in the commutated coils tending to set up short circuit currents through the brushes. The induced short circuit currents, being broken when the commutator bar passes out from under the brush, cause a momentary spark. The value of this induced current is influenced by the rate of change of the magnetism. It is, therefore, evident that a laminated field, although aiding in maintaining the desired field form, would accentuate this factor of inductance.

Effect of Design

Railway motors, even of the interpole type, must be liberally designed, particularly with a view to avoiding conditions favorable to flashing. The first requirement is a strong field relative to the armature magnetizing force in order to avoid excessive field distortion. This is secured by working the field iron fairly hard and designing the armature for a comparatively small number of conductors to keep the field weak. A wide air gap aids in offering a high reluctance path to the armature magnetization and saturation of the pole tips aids in preventing a peak in the field form at the edge of the poles. A large number of commutator bars reduces the volts between segments and also decreases the number of turns, reducing the inductive influence. The designer utilizes other additional details to further this purpose.

With the advent of the interpole, advantage was taken of its influence toward improving commutation and many motors were more closely rated and less liberally designed. This led to difficulties in some cases, as it was not fully appreciated wherein the functions of the interpole were limited in their application to railway motors. In recent designs many of the original features favorable to good commutation are retained, even though interpoles are used. Such motors are giving entire satisfaction.

Requirements for Flashing

The first requirement for flashing is a vaporizing arc. It is a difficult matter to set up an arc through air, but after the arc is once established, it is maintained comparatively easily. An arc lamp operates by separating two carbons carrying current. If the brushes of a motor be displaced from the commutator, an arc will be set up from the commutator surface to the brush. Such an arc is likely to be severe, and if the potential gradient is sufficiently steep, a flashover may easily ensue. It may easily happen that when the car passes over a rail joint or similar roughness in the track, the brushes are knocked away from the commutator by their inertia. This is most likely to take place when the car is running at high speed. It has been found that interpole motors, as well as noninterpole machines, flash frequently at high speed, although interpole motors seldom flash at low speed. Poor brush contact is a probable explanation. It should be noted also that at high speed the field is weak and the distortion more likely to be pronounced. The remedy for jumping brushes is heavier brush pressure. Tests have shown that the best all around pressure is about 5 pounds per square inch. This insures good contact, comparatively small brush friction and low contact resistance loss. The brush wear is not excessive under this pressure. The proper pressure depends partially upon the condition of the track, the rigidity of the motor suspension, the car speed, the commutating characteristics of the motor and its tendency to flash. It is well to use a five-pound per square inch pressure initially and to decrease it slightly if all is well. If trouble appears the pressume may be increased about two pounds. Pressures above seven pounds per square inch lead to rapid commutator and brush wear.

Action of Motor During Flashover

It is interesting to study the action of a motor during a flashover. When an arc is once established from brush to brush it is easily maintained by the line voltage. This arc short circuits the armature through a fairly low resistance path. The field is thrown directly across the line in series with the arc of little resistance. The field current thus rises to a very high value. We then have a thoroughly short circuited armature rotating through a strong field. This acts directly as a dynamic brake and stops the motor suddenly, causing the car wheels to slide.

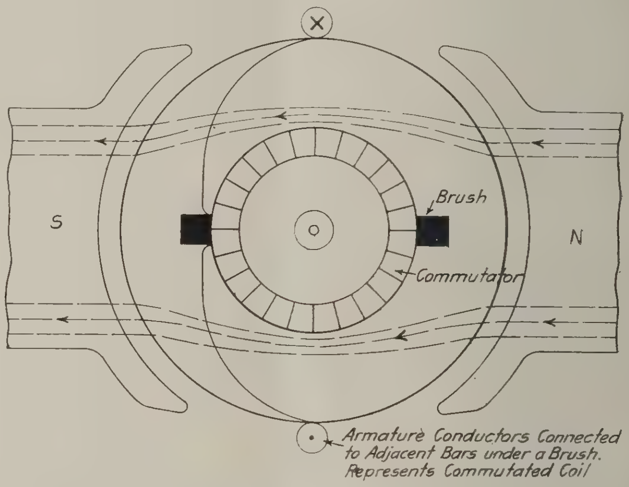

S
N
Brush
Commutator
Armature Conductors Connected to Adjacent Bars under a Brush. Represents Commutated Coil

Fig.2—Showing How Changes of Field Magnetism Induce Currents in Commutated Coil by Transformer Action

Not all motor flashes are from brush to brush. The arc formed at the brushes may spread from segment to segment along the commutator over that portion in which the segment voltages are high, corresponding to the peak of the field form curve. It then becomes more difficult for the arc to spread along the commutator so it rises with the ascending heat and jumps to some nearby portion of the grounded frame. The path frequently taken by a flashover to the frame is shown in Fig. 3.

Generator and Rotary Flashing

A flashover is of much the same character in a generator as in a motor, although the action and causes are somewhat different. There is one point of difference which favors the generator materially. The peak of a motor's field form curve is near the trailing edge of the brush where sparking is most violent. Any hot vapor is easily carried over into the zone of a steep potential gradient. In a generator the peak of the field is removed from the trailing edge of the brush and is nearer the leading edge, at which point there is little sparking.

As in a motor, commutation has an important bearing upon flashover tendencies. Nearly all generators for railway service are built with interpoles in order to secure the best of commutation. As in railway motors, the interpoles are not entirely effective under sudden load changes. The armature reaction builds up more rapidly than the compound fields or interpole fields because of the laminated construction of the armature as contrasted with solid construction of field yoke and poles. Consequently, for a short interval, the armature magnetization is unduly strong and sparking may arise sufficient to originate a flash. It may be seen, in this connection, why German silver adjusting shunts, especially if they are wound non-inductively, may lead to difficulties.

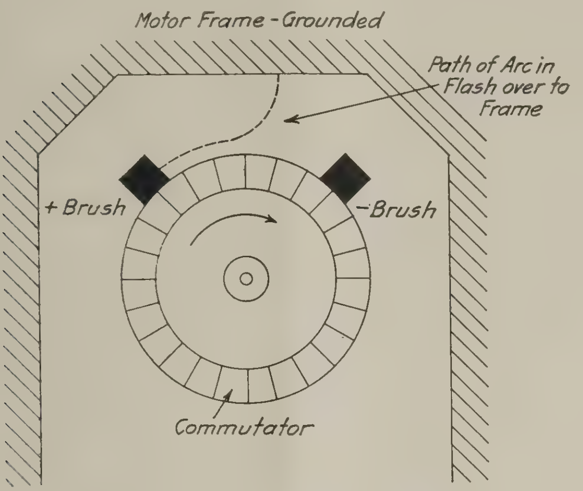


Fig. 3—Diagram Showing Path of Arc in Flashover to Frame in a Railway Motor

If the shunt is non-inductively wound it assumes most of the load during an increase, until the inductive interpole winding can build up its current. The interpole magnetizing influence does not then follow load changes closely. It is, therefore, desirable to wind any interpole shunt inductively about an iron core. A shunt around the interpole winding, in any case, forms a local circuit through the interpole winding and its shunt in series. This acts in the same manner as a short circuited damping winding surrounding the interpole iron. This prevents rapid change of interpole strength so that the interpole cannot adjust itself quickly to load changes. It is desirable to avoid shunting the interpole winding of any machine subject to wide and sudden load changes such as the railway generator which is representative of this class.

Ring Fire

Another commutation condition affecting the flashing tendency is ring fire. By ring fire is meant the fine red rings which travel along the surface of a commutator encircling it wholly or in part. Ring fire is, in reality, leakage of current across mica segments from bar to bar. The current leakage is encouraged by small particles of foreign matter, carbon or copper dust, embedded in the mica. Sufficient current flows through the leakage path thus afforded to bring the particles to incandescence. Their rotation imparts the appearance of rings. Graphite brushes coat a commutator with a thin glaze of semi-conducting nature which encourages leakage across the mica segments. Lubrication of the commutator with paraffine wax often leads to ring fire, particularly if the commutator is cool. The wax then gums and dirt easily adheres and collects. Oil has a detrimental influence, causing the mica to carbonize and burn and leading to severe leakage across the mica. Ring fire favors flashing because it sets up a small, but often continuous, path of hot vapor from one brush stud to another. If there is any tendency to flashing displayed, ring fire will accentuate it. The remedies for ring fire should be obvious, cleanliness of the commutator surface being the prime requirement.

Overloads

Ordinary steady overloads do not often lead to flashing. Excessive overloads, such as short circuits on the line, may easily do so. The armature current increases to several times normal value, distorts the field, shifts to neutral and causes large short circuit currents to flow across the brush face. The heavy load thus imposed on the brush tips causes vicious sparking. If the resulting copper vapor reaches to any nearby part of differing polarity a flashover is likely.

Large and sudden overloads are frequently in railway service. Plugging or flashing of motors, partial short circuits, trolley wire breaks, car barn switching and other similar causes lead to frequent severe loads from the lines. These short circuits and surges are the main causes of generator and rotary flashovers. It has been found by experience that a short circuit at some distance from the generating or rotary station does not affect the machines as severely as one close by. This has led to the practice of avoiding the connection of feeder taps to the trolley close to a station. The proper distance for the nearest tap depends upon a number of considerations.

Capacity of the System

The capacity of the generator or the energy behind a rotary converter has an important bearing. It is evident that for a rotary of given size the greater the capacity at the generating plant, the greater damage is likely to result from a flashover. The short circuit across the rotary brushes furnishes a low resistance path for the flow of an enormous current from the alternating current system. The opening of the alternating current circuit breaker relieves this condition, but during the short interval considerable damage may be done. The duration of a flash may be decreased by interlocking the direct current to the alternating current circuit breaker so that both are tripped simultaneously in case of an overload on the rotary of sufficient magnitude to cause a flash.

Because of the through electrical connection of a rotary to the supply system a flash is likely to be more severe than is the case with an engine driven generator or a motor generator set. The greater inherent resistance and reactance of the generator windings and the cushioning effect of the motor relieves conditions somewhat for that type of machine. A generator must suppress only its own generated power, but a rotary has usually a much greater supply to be considered.

The relative size of the rotary or generator with respect to the car motors has a bearing. A large generating unit is less likely to be seriously affected by a line disturbance of given magnitude than is a machine of smaller relative capacity.

Voltage and Feeder Taps

The voltage of the system has a direct influence. Generally speaking, the feeder taps for a 1200 volt system must be placed about twice as far from the generator or rotary as in a 600 volt system.

The size of the feeders affects the resistance interposed in case of a short circuit. The larger the feeders the longer should be the tap distances. Each feeder of the system should handle about the same amount of load. If any one feeder transmits a great portion of the station output, any trouble upon that line is likely to affect the station more seriously than would be the case if smaller, equal feeders were used. Since the rails form part of the transmission system their weight and the quality of their bonds influence directly the resistance in series with a short circuit out on the system. Heavy rails, well bonded, require longer tap distances.

It will be seen that there are many conditions influencing the selection of the proper tap distances. In general, the taps on a 600 volt system should not be nearer than 2500 feet. If flashing is frequent with this arrangement the distance must be increased until it stops. The longer the feeders the greater will be the line drop and line loss, but these factors are of minor importance as compared with interrupted service and damaged machines.

Where it is inconvenient to lengthen a feeder or where it is desirable to connect to the trolley at a point near the station a permanent resistance may be substituted for an equivalent length of feeder cable. The same results are secured as with long feeders.

The protection for the generating equipment may be arranged to minimize troubles arising from severe line disturbances. Where there are several feeders from a single generating unit the feeder circuit breakers should be set as low as permissible and the machine circuit breakers set relatively higher. The machine circuit breaker might even be equipped with a time relay to enable the feeder breakers to operate first. This arrangement clears the troublesome line quickly before the machine breaker opens and perhaps before any severe trouble upon the generator or rotary. As previously mentioned, interlocking the direct and alternating current overload devices of a rotary may offer greater protection than would be afforded by their individual action.

Sudden Relief from Load

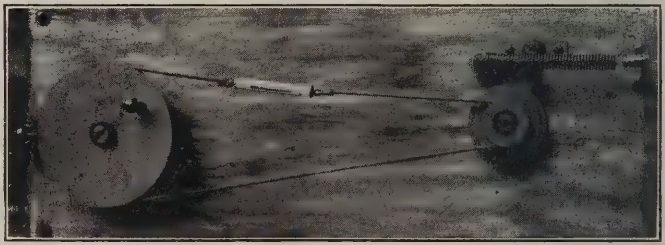
Flashovers are sometimes attributed not alone to sudden overloads, but also to sudden relief from load caused by the opening of a circuit breaker. In some cases this conclusion is incorrect since the flashover starts in reality during the brief interval required by the circuit breaker to operate. It may then continue after the breaker has cleared the line. Sudden interruption of a heavy load may cause trouble, however. An almost instant drop of armature magnetization occurs, accompanied by a less rapid falling off of the main field strength. An unbalanced condition then obtains. Particularly if the brushes are widely shifted for overload conditions, the quick shift of the neutral may give rise to a vicious spark, encouraging a flash. The sudden drop in magnetism within the armature also causes an inductive kick which may lead to trouble. Interpoles may have a detrimental influence when the load is suddenly released from a generator. The armature magnetization, falling off more rapidly than that of the interpole, shifts the neutral temporarily. The commutated coils are thus located in a zone of strong interpole flux. Being short circuited by the brushes, a violent spark will be thrown off sufficient to set up a flashover.

Failure of A. C. Voltage

A common cause of flashing on some rotary converters is failure of voltage on the alternating current line for short periods of time, allowing the converter to drop out of step. The results are more severe in the case of interpole machines. Protection against this difficulty can be secured in the case of a single isolated unit by equipping the alternating current circuit breaker with a low voltage release which will cause it to open when the voltage falls to a predetermined value. This method of protection does not apply in cases where it is possible to obtain reverse current from the direct current end to hold up the alternating current voltage in case of failure. Where converters tie in to live feeders or operate in parallel and are not subject to the same voltage conditions it is recommended that a direct current reverse current device be employed to trip the alternating current circuit breaker which is interlocked with and trips the direct current circuit breaker. The reverse current device actually secures protection from low alternating voltage.

Safety Belt Tension Device

The Safety Car Heating & Lighting Co., New York, exhibited at Atlantic City an interesting model which demonstrates the basic principles of its constant belt tension device as employed in the "Under-frame car" lighting generator. This model is fitted with a miniature axle pulley, generator and spring tension device, all built to correct scale, weight ratio and spring power. A delicate spring tension balance is inserted in the belt and this indicates at all times the exact tension on the belt. The model is fitted with a takeup device by means of which the distance between car, the axle and the generator support can be changed, as is necessary every time the car rounds a curve.



Model Showing Constant Belt Tension Feature of Safety Underframe Suspension.

The movement in the model is such as would correspond to an 8 in. movement in the generator. A two inch generator movement is about the maximum swing when the generator rounds the sharpest curves encountered; but the model demonstrates that even though the generator swing may be four times this, the belt tension is maintained at a constant value. This compensates for any reasonable amount of belt stretch in service.

Anti-Friction Bearings for Motors

Some Engineering Opinions on This Subject Expressed by Engineers and Users

Horace Niles Trumbull[*]

THERE has been such an interest manifested in the application of anti-friction bearings to electrical machinery that a series of questions was recently submitted to anti-friction bearing motor engineers and users throughout the country in order to obtain their opinions as to the advantages gained. The following engineering opinions are typical of those received in the answers.

O. W. Bricker, mechanical engineer of the Lincoln Electric Co., Cleveland, Ohio, which company uses ball bearings on both vertical and horizontal battery charging sets, states:

> "About 95 per cent of our ball bearings are used on an electric automobile charger. Our reason for adopting the ball bearing on this outfit is due to the lack of attention given to the old style babbitt bearing. By the use of ball bearings we are able to lubricate the machine before leaving the factory and owing to its intermittent use, it will require no attention from the user for a period of at least one year. We have also brought out a line of 3,600 r.p.m. motors. By the use of ball bearings on these high speed machines the lubrication troubles are reduced to a minimum. It might be of interest to you to know that in our particular case we have sold this year four times the quantity of ball bearing motors we have previously sold."

N. D. Levin, chief engineer, mining department, Jeffrey Mfg. Co., Columbus, Ohio, which equipped its mining locomotives and coal cutting machinery with ball bearings, states:

> "We adopted the use of ball bearings about seven years ago, and are now using ball bearings altogether. Mining machinery receives less care and attention than any other class of machinery. Where ordinary sleeve bearings were used, the bushings were allowed to wear out, and consequently the armatures would rub on the pole pieces until they burned out. This difficulty has been overcome to a great extent, as the ball bearings last a long time, if dirt is excluded and they get oil occasionally. Some of the first ball bearings that we furnished are still in operation. Customers who have purchased machinery equipped with ball bearings, in late years, realize the advantages of them, and very often go to great expense to have changes made in their old machinery so as to enable them to adopt ball bearings."

G. Lindstrom, Electric Products Co., Cleveland, Ohio, manufacturers of Wotton battery charger, states:

> "We find that ball bearings have the following advantages over ordinary sleeve bearings: Simplified design of bearing housing with consequent reduction in cost of production; reduced overall length of the machine, as it is possible to mount the bearings close to the center of gravity of the revolving parts, thus reducing the chances of vibration caused by deflection of the shaft; easier and more reliable method of lubrication as the bearings can be packed with lubricant and can be so enclosed without difficulty that the lubricant cannot leak out. This makes it possible to reduce the maintenance cost, as frequent oiling and inspection is not necessary. Our experience shows that semi-annual inspections are all that are required. The bearings can also easily be made dustproof.
>
> "We are firmly convinced that the tendency is to increase the use of ball bearings on account of the advantages given above. This is shown by developments in Europe as well as in the United States where more of the prominent manufacturers of electrical machinery now are prepared to give the buyer the choice between ball and sleeve bearings. The above statements are based on our experience with several thousand motor generators equipped with ball bearings. The exceedingly small number of cases of bearing troubles that we have had is the best testimony in favor of using ball bearings in electrical machines.
>
> "On a vertical machine, it is necessary to provide a thrust bearing and my past experience in designing vertical motors has plainly indicated that a ball bearing is the only reliable thrust bearing. For the radial load a ball bearing has proven its superiority to any other type of bearing, a fact that is being acknowledged by all designing and operating engineers."

A. W. Forbes, of Forbes & Myers, Worcester, Mass., manufacturers of electric grinders, states:

> "We are using ball bearings exclusively and believe that the advantages more than make up for the additional cost in electric motors. While we think that the use of ball bearings on motors will increase, there will probably always be a demand for the cheaper machine with plain bearings.
>
> "With regard to efficiency, the use of ball bearings makes but little difference in small machines such as we manufacture. Bearing friction is nearly eliminated, but that is but a small part of the losses. The principal advantages in the ball bearing are those that make for reliability. With the small clearance between rotor and stator in the induction motor, a small amount of wear is a serious matter. With a high grade of ball bearing, wear is practically eliminated. Even faulty lubrication that would ruin a plain bearing, does not ordinarily have much effect on the ball bearing."

H. K. Spencer, engineer, Blanchard Machine Company, Cambridge, Mass., manufacturers of grinders and vertical motor driven spindles, states:

> "The chief advantage, as applied to a motor would seem to be the certainty that the shaft will be kept in its proper place, eliminating all possibility of the armature getting off center, due to wear of bearings. The power saving is probably a very small item, but there is some advantage in not having to lubricate so often."

L. W. Householder, electrical engineer, Rochester & Pittsburgh Coal & Iron Co., Punxsutawney, Pa., states:

> "About three years ago, we started a very complete investigation as to the cause of armature and field trouble on our mining locomotives. We found that about fifty per cent of the failures were due to oil soaked commutators and windings and ten per cent. due to rubbing of the pole pieces. We started at once to change our armature bearings to ball bearings and to buy all of our new locomotives with ball bearing armatures. Today we have the following locomotives operating with ball bearing equipment: 30 GE. ten-ton locomotives; 16 GE. six-ton locomotives; 5 GE. fifteen-ton locomotives, 3 motor, 6 wheel; 6 GE. twenty-ton locomotives, 3 motor, 6 wheel; 8 Jeffrey ten-ton locomotives, and 4 five-ton slage laries.
>
> "These locomotives have been operating continuously in our regular mine service from six months to two and a half years, and we have had remarkable success as we have only replaced two ball bearings; one due to incorrect assemble, the other one due to the sand getting into the lubricant. We have one ten-ton locomotive that operates approximately 55 miles every day and has been doing this for two years, and I personally examined the ball bearings on this locomotive a short time ago and at the present rate of wear they will last approximately five years.
>
> "We have entirely eliminated all of our trouble with oil-soaked commutators and windings and never hear of a ball bearing armature being down on the pole pieces. Our records show

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[*] S. K. F. Ball Bearing Company, Hartford, Conn.

that we have eliminated about 60 per cent of our motor troubles by using ball bearings."

Ira H. Spencer, president of the Spencer Turbine Cleaner Co., Hartford, Conn., makers of electric vacuum cleaners, states:

"We use ball bearings in our 3500 speed vertical motors from ½ to 30 h.p. for the reason that we found no other bearing that would stand up under the severe conditions."

A. Bourgeois, sales manager of the Eck Dynamo & Motor Co., Belleville, N. J., which uses ball bearings on horizontal motors, states:

"Regarding the advantages accruing from the use of ball bearings in electric motors, wish to state that in our opinion very real advantages are obtained in the matter of maintenance, working efficiency, cleanliness and greater mechanical strength of shaft; also greater compactness of motor, making it better adapted for individual application to machinery.

"Another advantage afforded by the use of ball bearings is the solidity of the mechanical construction which makes it possible to install the motor on floor, sidewall or ceiling without any mechanical changes."

M. Pfatischer, chief engineer of the Electric Dynamo Co., which uses ball bearings on Inter-pole motors in sizes from 1 to 150 h. p., states:

"My company has been using ball bearings on inter-pole motors in sizes from 1 to 150 h.p. for the last ten years with excellent results. Ball bearings offer less friction, are cleaner and require less attention than the regular sleeve bearings. They also take up considerable less space."

Frank E. Fisher, electrical engineer, Diehl Mfg. Co., Elizabeth, N. J., manufacturers of electrical machinery, states:

"The field of usefulness so far as the Diehl Company is concerned is governed by the following ball bearing applications:

"(a) Electric vehicle motors—The reasons for use on this class of work are as follows: (1) Increased motor efficiency, decreased weight and dimensions. (2) Bearings require less attention. (3) Service is such that it is almost impossible to use sleeve type bearings.

"We have been using ball bearings in vehicle motors for over six years, and comparatively speaking, have had but little trouble. During the past year, for baggage truck motors which come under the same class, we have used approximately 2000 ball bearings and are pleased to state that we have had no bearing troubles reported.

"(b) Vertical motors—We have built a limited number of vertical motors for government work with ball bearings, and have had no troubles reported to date.

"(c) Railway motors—We have built a large number of railway type machines for mining locomotives, storage battery street cars, etc., and in addition to the reasons stated under (a) the additional reason of limited space applies in this case. We can materially shorten the overall length of the motor by the use of ball bearings.

"(d) Dynamometers—We have used a number of ball-bearing equipments for this service, where the speeds are very high, and the weights of armature are comparatively heavy.

"(e) Enclosed motors for pump duty—An enclosed motor has a tendency to create a vacuum directly over the bearing, and as a result, oil is pulled out of the bearing into the motor. We are furnishing this type of motor now, with ball bearings, to prevent this trouble. As a general rule the ball bearings need attention about twice a year."

A test by another motor manufacturer gives the following data: Three 3 hp., 1800 r.p.m., induction motors back geared 7 to 1, were tested. The motors were of identical construction, except that one was equipped with ring-oiler bearings, another with waste-packed bearings and the other with ball bearings. The tests showed the following efficiencies: Ring-oiler bearings, 81.5 per cent; waste-packed bearings, 80.5 per cent; ball bearings, 84 per cent. The difference in efficiency between ring-oiler and ball bearings was in this case 2.5 per cent. Let us see how this difference in efficiency figures out with 20 motors with ring-oiler and ball bearing equipment. Assume that the motors are running 3,000 hours per year and running at their rated capacity.

20 x 3 x 3000 x 84%=151200 hp. hr. for the ball bearing motors.
20 x 3 x 3000 x 81.5%=146700 hp. hr. for the ring-oiler motors.
4,500 hp. hr. saving.

At 1 cent per hp. hr. the saving effected by the use of ball bearings amounts to $45.00 per year. This saving is in the mechanical efficiency only and is in addition to other greater and more important economies noted previously.

The following is an illustration of how ball bearings maintain the original bearing setting of the armature: At the Indianapolis plant of the Fairbanks Morse Co. there is a 200 k. v. a., 600 r. p. m., 3 phase, 60 cycle, 2300 volt synchronous motor equipped with ball bearings. The motor drives two generators by 10 in. belts; on one size, a 25-cycle ac. generator; on the other, a dc. generator. The machine has been running continuously for over three years. The plant operates 56 hours per week regularly and the motor frequently runs 18 to 24 hours a day when machines are being tested. When the motor was installed the height of the shaft above the base was accurately measured. Up to the present time the gage measurement has not been able to detect any drop of the shaft, proving conclusively that the ball bearings during these three years of almost continuous operation have not worn down a measurable amount.

Among the principal advantages of ball bearings on motors is that the bearing adjustment remains constant, thus keeping the rotor in the center of the magnetic field. This permits the motor manufacturer to employ air gaps with clearances so slight that they could not be considered on motors having any other type of bearing. On induction motors a close air gap is of vital importance in the improvement of the machine efficiency and the motor power factor.

Chief among the difficulties with plain bearings is the fact that after a period of service the bearings wear down to an amount varying with the load and service conditions. This wear continuing, it will finally permit the armature to touch the pole pieces with resulting trouble, perhaps a stripped armature or a burned out armature, due to the increased friction load. In a ball bearing, hardened steel balls roll on hardened steel bearing races, rubbing friction is practically eliminated and accuracy of air gap is maintained.

Summarizing, the advantages offered by anti-friction bearings are: Smaller air gaps and therefore improved power factor; cheaper operating; longer periods between motor inspection; inspection and lubrication charges, therefore, greatly reduced; security against leakage of oil; improved commutation; fewer repairs; saving in motor length of from 10 to 20 per cent; greater durability and decreased friction, especially at starting, and improved motor commutation. Ability to ship the motor fully lubricated and ready to run, and to place it in any horizontal running position desirable without making mechanical changes are also important advantages.

An Electrified Car Ferry

THE Oakland, Antioch and Eastern, an electrified line, operates between Oakland and Sacramento, Cal., with boat connections from San Francisco, running a total of seven electric trains daily each way. Five of the trains connect at the M street bridge in the outskirts of Sacramento with trains of the Northern Electric Railway running to Chico. Three trains each way carry parlor observation cars, and on one of these trains the parlor observation car is carried through between Chico and Oakland so that no change of cars at Sacramento is necessary. The system also has two seven-mile branches, one to Antioch and the other to Danville, making a total of approximately 150 miles of route, which is efficiently protected by block signals throughout.

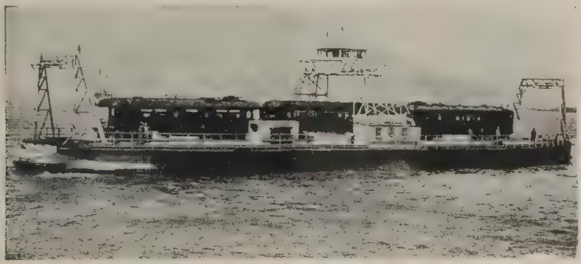


Fig. 1. View of the Oakland, Antioch and Eastern's Car Ferry "Ramon."

To avoid the necessity of making passengers change cars in order to cross Suisun Bay the railway transports its trains across the bay from Bay Point to Chipps Island. It is planned to have a bridge 10,000 feet long and 70 feet high span this bay, but while the structure is being built the railway ferries its trains across on the gasoline-engine-driven car ferry illustrated. The Oakland, Antioch and Eastern is the only electric railway in the United States that ferries its cars with passengers aboard in order to make change of cars en route unnecessary.

The car ferry is known as the "Ramon" and was designed and built by the Oakland, Antioch and Eastern. The Ramon is constructed entirely of steel, is 185 feet long, and weighs 590 gross tons. It is driven by a 600 horsepower eight-cylinder gasoline engine of the electric ignition type, built by the Union Gas Engine Company of San Francisco and has sufficient capacity to carry six loaded passenger cars or eight freight cars. The engine is of unusually massive construction, weighing approximately 120,000 pounds.

A noticeable feature of the ferry is the absence of curved plates and the adoption of a box-like design with ends that are extremely flat in order to present a large area of displacement to overcome tipping while loading or unloading cars. There are three tracks on the main deck, each 220 feet long, having a total capacity of nine cars. As will be seen from the illustration of the car ferry, there is an overhead catenary construction so that the trains are able to run off the ferry under their own power.

To meet the demand of the heavy passenger traffic the Oakland, Antioch and Eastern employs single motor cars, multiple trains, and trains hauled by high speed electric locomotives. All the electrical equipment, including that for cars, locomotives, substations and line material, were furnished by the Westinghouse Electric & Mfg. Company, of East Pittsburgh, Pa. The railway operates eighteen standard motor passenger cars and several palatial parlor cars and coaches. The standard cars are 56 feet long, weigh 87,300 pounds each and are divided into express, main passenger, and smoking compartments. The parlor cars, which are hauled on express trains, have a buffet and seat sixty persons. They are fitted up with appointments equal in every way to parlor cars operated by steam railroads and thus the system offers as complete comfort to the traveller as can be secured on competing steam lines, with the added comfort of freedom from smoke, etc. Each motor car is equipped with four Westinghouse 120 horsepower, 600-1200 volt commutating pole motors, and 1200 volt HL control.

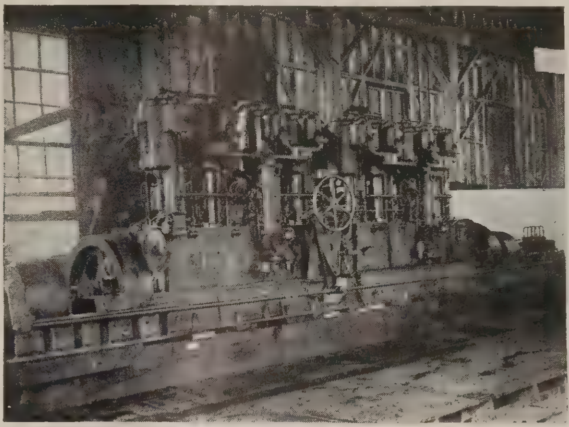


Fig. 2. The 600 H.P. Gasoline Engine.

Since the opening of the road the passenger traffic between Oakland and Sacramento has increased so rapidly that in order to meet the demands it has been necessary to supplement the multiple unit trains and cars by electric locomotive hauled trains composed of standard passenger coaches. For this purpose four articulating truck, high speed, 62-ton Baldwin-Westinghouse electric locomotives are employed. Each is equipped with four 250 horsepower, 600-1200 volt, commutating pole motors, geared 24:47 with 42-inch wheels, giving a maximum permissible speed of 70 miles per hour. These locomotives are able to haul five steel 37½-ton coaches on a level tangent track with 1100 volts on the trolley, at a balancing speed of 56 miles per hour. HL control mounted in the center of each locomotive cab controls the power to the motors. The use of electric locomotives on an interurban road in this manner is a new and noteworthy application in the electric railway field.

In addition to the passenger traffic the railway also handles considerable through and local freight and baggage between Oakland and Sacramento. For this purpose two 47-ton, slow speed, Baldwin-Westinghouse electric locomotives are used, of the steel cab type with swivel trucks, and equipped with four 120 horsepower 600-1200 volt commutating pole motors and HL control.

The Illuminating Engineering Lecture Course

Dr. Louis Bell

IN 1910 the Illuminating Engineering Society, in co-operation with the Johns Hopkins University, gave a course of lectures on Illuminating Engineering, which went far toward placing before the public the general principles of the art. In the six years which have since elapsed there have been many changes in methods, improvements in apparatus, and developments in theory, which seem to call at the present time for another effort at education in illumination.

The course now being inaugurated is the result again of co-operative effort, and is to be given by the Illuminating Engineering Society under the auspices of the University of Pennsylvania. Its scope is intended to be somewhat different from that of the first course of lectures in which the principles of an art and its applications had to be laid down substantially for the first time in a general course of instruction. The present course is directed specially toward the practical application of these principles to the work of illuminating engineering as carried on today by the latest methods and with the most recent equipment. It ought to appeal with particular force not only to the engineer, but to those whose contact with illuminating engineering is chiefly commercial. It should impress upon those, who in their daily task have to deal with the applications of artificial light, a firmer grasp of advantageous methods and a closer understanding of the things which are necessary to make electricity and gas of the maximum usefulness to the consumer.

The following preliminary list of subjects for the Illuminating Engineering Society-University of Pennsylvania lectures has been issued:

Subject	*Number of Lectures*
(A) General:	
1 The Principles of Interior Illumination	2
2 The Principles of Exterior Illumination	1
3 Color in Lighting	1
4 Architectural and Decorative Aspects of Lighting	1
5 Recent Developments in Electric Lighting Appliances	1
6 Recent Developments in Gas Lighting Appliances	1
7 Modern Lighting Accessories	1
(B) Special Lectures on Interior Illumination:	
8 The Lighting of Factories, Mills and Workshops	1
9 The Lighting of Offices, Stores and Show Windows	1
10 The Lighting of Schools, Auditoriums and Libraries	1
11 The Lighting of Churches	1
12 Theatre Lighting (Including Stage Lighting) and the Lighting of Art Museums	1
13 The Lighting of the Home	1
14 Train Lighting	1
(C) Special Lectures on Exterior Illumination:	
15 Street Lighting	2
16 The Lighting of Yards, Docks and Other Outside Works	1
17 Headlights, Searchlights and Projectors	1
18 Sign Lighting	1
19 Building Exterior, Exposition and Pageant Lighting	1

Facts About the Lectures

Time—September 21-28, 1916; immediately following annual convention of Illuminating Engineering Society in Philadelphia.

Place—Engineering Building, University of Pennsylvania, Philadelphia.

Auspices—Jointly those of the Illuminating Engineering Society and the University of Pennsylvania.

The new lecture course will include the principles of illumination and various aspects of lighting practice. Whereas the 1910 course emphasized the science of illumination, the new course will emphasize the art of illumination, and will include about 20 lectures by men selected on account of their qualification to deal authoritatively with the several phases of the subject.

The personal of the I. E. S. Committee of Lectures having charge of the preparation of syllabus and the selection of lectures is as follows:

E. P. Hyde, Chairman; Louis Bell, L. B. Marks, C. H. Sharp, Secretary; W. H. Gartley, W. D. Weaver.

The personnel of the I. E. S. Administrative Committee on Lectures is as follows:

P. S. Miller, Chairman; C. E. Clewell, J. D. Israel, A. S. McAllister, H. K. Mohr, C. O. Bond, F. H. Gale, C. L. Law, W. J. Serrill, G. H. Stickney.

The personnel of the University committee having charge of participation in the course and the departments with which connected, is as follows:

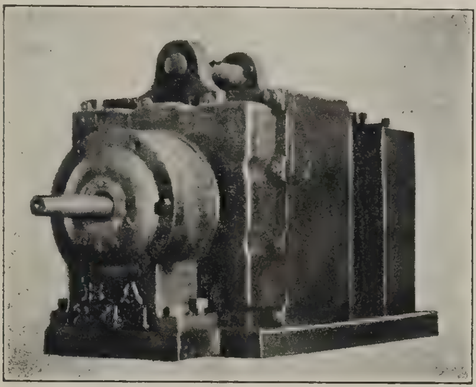
Prof. C. E. Clewell, Electrical Engineering; Prof. G. E. deSchweinitz, Ophthalmology; Prof. R. H. Fernald, Mechanical Engineering; Prof. A. W. Goodspeed, Physics; Prof. W. P. Laird, Architecture; Prof. Harold Pender, Electrical Engineering; Prof. W. T. Taggart, Organic Chemistry.

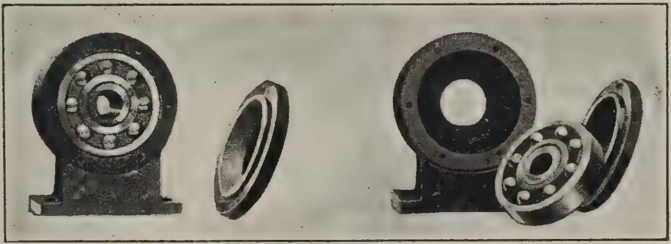
The price of tickets for the lecture course has been fixed at $25 which includes admission to all lectures and functions associated with the lecture course, partial or entire, reprint of the 1910 lectures and reprint of the new lectures. The tickets will be available about July 1, and may be obtained in advance from C. L. Law, chairman of the sales committtee, care of the New York Edison Company, 15th street and Irving Place, New York. Checks in payment for tickets should be made out to W. J. Serrill, who is chairman of the Finance Committee.

Practical Stunts

Ball Bearings for Consolidated Type A Axle Generator

The three views show a ball-bearing pillow block which was designed by the writer for a Consolidated Type A axle generator. The number 412 size of ball-bearing was used to prevent carrying so many sizes in stock. All the holes are drilled by a jig which makes all parts interchangeable. It is not necessary to throw away the old shafts if they are in good condition, as there is no change necessary in the shaft except on the pulley end. We turn the shaft down to 1 7/16 inches and, afterwards, an adapter which fits the bearing is slipped on. A thread is then cut on the shaft to lock the bearing in place. The lock nuts are inside the housing. All new shafts are made with solid sizes to fit the bearings without the use of an adapter.





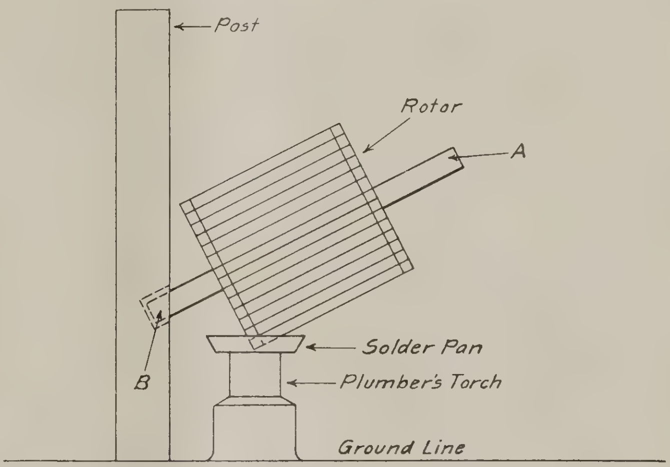
J. H. Burcham,
Ch. Elec., Chicago & Eastern Illinois,
Danville, Ill.

Soldering End Rings

Until recently the end rings and bars on the rotor of an induction motor have been bolted and soldered together to make a good electrical and mechanical connection with each other, but at present these connections are either electrically welded or cast into one solid mass by the manufacturers. As the majority of all induction motors in use are of the older types, which have soldered and bolted end ring connections with rotor bars, it would seem advisable to have some quick, practical and economical method of resoldering these rotor bars to the end rings which can be used by the shop electrician on the shop grounds without sending the rotor to an outside repair shop.

The following method is one which has been successfully used by the writer for some time: A solid post or block of timber is drilled or chiseled out large enough to receive the end of a rotor shaft, as shown at *B* in the sketch. A quantity of half and half solder is then melted in an iron soldering pan over a plumber's torch and kept hot while the workman gradually turns the rotor around while holding it by the other end of shaft at *A*.

After one end has been soldered the opposite end of the shaft is put in the post and the rings at that end soldered in a similar manner.



When a rotor is too heavy to handle by hand a rope may be tied to the top of the post and the outer end of the shaft to support it during the soldering process. This is recommended even on small rotors as a safety precaution against spilling the melted solder.

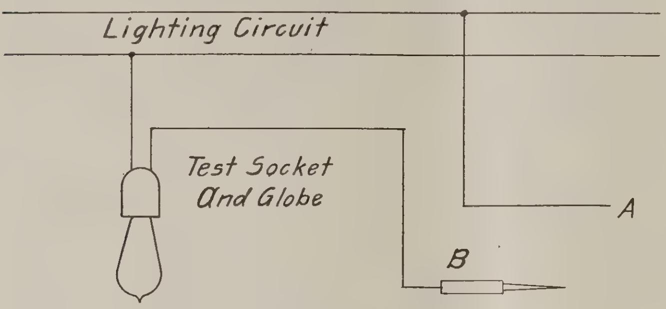
J. H. Wickman,
Illinois Central, Chicago, Ill.

Separating Coil Groups in Induction Motors

Whenever it is necessary to make any changes in the end connections of an induction motor or to cut out a coil, the average shop electrician will say, "Can't do it, they all look alike to me." The latter part is true, as the coils being placed in a symmetrical manner in the slots do look alike. However, if the principles of winding are understood the different groups of coils may be separated so that they do not "look alike" and the connections necessary for changing the grouping may be made.

The method used by the writer for picking out different groups of coils in each phase of the winding may be readily understood by referring to the diagram. A common weatherproof socket is connected as shown to a lighting circuit and the wire *A* is taken from the opposite side from which the socket is connected, so if the two ends, *A* and *B*, are touched together the lamp will light. Nearly all electricians use this testing connection, but when testing for ends of coils or groups of coils it will be found by connecting a sharp pointed piece of iron, or a pocket-knife with a small sharp blade, to one end as at *B* the insulation can be pricked without breaking it and a dozen or so tests can be made in the time it would take to peel the insulation and retape it.

By connecting the end of the wire *A* to the end of one phase and by having the neutral connection between phases open, any coil or group of coils in this one phase may be picked out from the others within two or three minutes at the most by simply pricking the insulation with the knife attached to *B*, where the end connections are made. This same method is practical for finding grounded or open coils, because if an open is bridged the lamp will light.



The writer has always found a small dry battery and buzzer fully as reliable for making these tests when connected in a similar manner, that is, the battery represents the lighting circuit and the buzzer the lamp. However, a magneto cannot be recommended, as it is liable to ring through a weak spot in the insulation and thus deceive the person making such tests.

J. H. Wickman,
Illinois Central, Chicago, Ill.

"American" Cork Inset Pulleys

The advantages of using cork inset pulleys, especially on main drives, are not generally appreciated. Belt slippage, in many cases, is not an evidence of a faulty pulley but an indication of a too heavily loaded or greasy belt. If the load is too great, another pulley must be added to the shaft or a large pulley installed. Another remedy for this condition is found in a pulley fitted with cork insets. The corks, which are firmly set in the steel, wear indefinitely, are practically unaffected by dust, oil, or water, and give to the pulley face an extra gripping quality.

The loss that occurs from the slipping of belts reduces product, reaches back to the coal pile and means waste, while, on the other hand, the failure of certain machines to operate at the desired speed means loss and in some cases a defective product. To overcome these difficulties, in a great many cases, pulleys are lagged and relagged, belts are run under excessive tension, to the injury of the belt and with an increase in the journal friction far beyond economical operating conditions. Belt dressing is used—sometimes in large quantities and to an extent that means an appreciable yearly charge to the expense account.

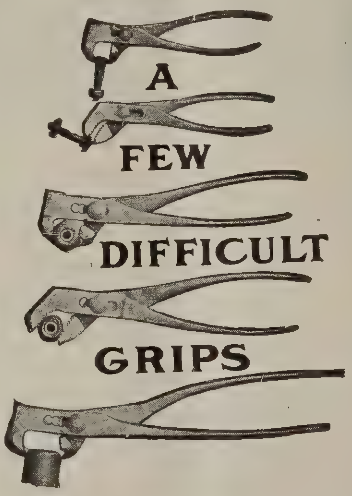
If cork insets are used in pulleys where these conditions exist, lagging, excessive belt tensions, and belt dressing are unnecessary. It is interesting to note the results of extensive tests made at the Lowell Textile School and the Worcester Polytechnic Institute:

Percentage of gain of steel pulley with cork insets over same without insets	60 per cent less belt slip
Percentage of gain of iron pulley with cork insets over same without insets	51 per cent less belt slip
Percentage of gain of wood rim pulley with cork insets over plain steel without insets	42 per cent less belt slip

For heavy drives with cork inset pulleys and little or no belt slip, the first thing to be considered is the width of belt required to transmit the load without overstraining the belt. The face of the pulley should be suitable for the belt, bearing in mind that "American" pulleys, manufactured by the American Pulley Company of Philadelphia, are good for all that should be put on a double leather belt of best quality. If the drive is excessive, so that the belt has to be overloaded, a special pulley of proper design and capacity had better be called for.

The Eagle Claw Wrench

A wrench recently placed on the market by the Mechanical Specialties Company, of Chicago, Ill., has been given the name of Eagles' Claw because of its ability to hold anything placed in its specially constructed jaws. The particular feature of this wrench is the design of its jaws. The tip end of one jaw is provided with a notch which gives two points, the other jaw has only one point which fits into the notch on the other jaw. This gives a three-point grip on any object whether it is round, hexagon, oblong or square. The Eagle Claw wrench should be especially useful to wiremen and machinists on steam railroads because of the great variety of pieces that it will firmly hold. A few of the most difficult grips are shown in the illustrations. This wrench is made in three different sizes, 7, 10 and 13 in. The 7-in. wrench holds from 0 to 1 in., the 10-in. from 0 to 1¼ in., and the 13-in. from 0 to 1½ in. The 7-in. wrench is particularly handy as a pocket tool.



General News Section

C. H. Ketcham, superintendent of the Stockton division of the Southern Pacific, has presented gold watches to two boys 11 and 12 years old, respectively, who averted what might have been a serious accident on June 4, when an irrigating canal broke its banks and flooded the railroad tracks near Arena, Cal. The boys saw the danger and flagged the trains.

The Pennsylvania Railroad reports that, in the first six months of the present year, 92,380,184 passengers were carried on the company's lines without loss of the life of a single one of them in a train accident. This completes two and one half years in which no passenger has been killed in a train accident on any part of the Pennsylvania System, either east or west of Pittsburgh.

An extensive system of military telegraph lines is being constructed along the Rio Grande river by army signal corps. The wires will connect the different supply bases with the headquarters and patrol camps that are scattered along the river. From Alpine, Marfa and Marathon the lines run to Shafter, Presidio, Terlingua, Boquillas and other points in the Big Bend region. The lines are of a permanent type of construction, and it is supposed that they will be left to serve any future emergency.

"Safety First" Interrogatively

Is there not really a better slogan for safety first than Safety First? The London Omnibus Company has decided to adopt in its place the suggestive question—IS IT SAFE?

The main idea underlying the words "Is It Safe?" is that if the question be mentally asked of oneself in a perilous moment, it instantly directs attention to the dangers present, wherein the instinct of self-preservation will assert itself, and this is in most cases all that is necessary to induce watchfulness and care. The slogan "IS IT SAFE?" was adopted by the Great Western Railway of England three years ago, and it is thought by the management that it meets with more general and hearty co-operation on the part of employees than the American slogan "Safety First."—*The Frisco-Man.*

To Extend Electric Operation on Norfolk & Western

The Norfolk & Western proposes to soon extend its electric operation of trains from Vivian, W. Va., westward 10 miles, and also from Welch up Tug Fork Branch for five miles. The new construction necessary will begin in the near future.

As recently described in the *Railway Electrical Engineer,* the Norfolk & Western has found the use of electric motive power between Bluefield, W. Va., and Vivian efficient and reliable. This section, which is 28 miles long, is one of heavy grades, and includes an important tunnel through which it is necessary that schedule time be always maintained and the working capacity of the line be likewise kept at its maximum of efficiency. Big coal trains are pulled over this route between fast passenger traffic, yet so reliable has the electric power been found that they are allowed to enter the tunnel only four or five minutes ahead of expresses, as there is afforded ample assurance that no blockade will happen.

The addition of the proposed electric mileage will amount to more than 50 per cent of the first installation and will make the total length of line so operated 43 miles. That further extensions will be made hereafter is apparently to be expected.

Pennsylvania Adopts Green for Proceed

The Pennsylvania Railroad announces that orders have been given for the adoption of the green-yellow-red scheme for the night indications of signals on its lines; and the order includes not only fixed signals but also markers on the rear of trains; switch lamps; markers for track tanks; slow signs; resume speed signs; hand lamps at interlocking and block signal stations, and lights displayed to the public at crossings. Lights at highway crossings will be red instead of green, as at present.

It is expected that the change will require some little time for its accomplishment. The number of glasses to be changed runs into the hundreds of thousands and, because of present industrial conditions, deliveries of material may be slow.

Green for proceed and yellow for caution have been in use at the Pennsylvania terminals, New York City, for six years past.

The "position-light" signals on the main lines of the Pennsylvania, near Philadelphia, are not affected by the new order.

Personals

C. R. CORBIN, who has been transferred from Pittsburgh, will be temporarily in charge of the Buffalo office of the National Metal Molding Company, Pittsburgh, during the absence of L. S. Montgomery, now on the Mexican border with Troop I, First Cavalry, New York National Guard.

F. W. REED, who, until July 1, 1916, was general foreman electrician of the Northern Pacific, has been appointed chief electrician vice E. R. Manor, who has been appointed assistant valuation engineer in the mechanical department for the same company. G. E. Brown has been appointed general foreman electrician. Mr. Reed will have general supervision over all electrical work on the Northern Pacific, including car lighting, outside and inside electrical construction and shop power and lighting and will make his headquarters in the Northern Pacific building, St. Paul, Minn.

EDWIN L. WILLSON, for the past five years sales engineer in charge of the railroad department of the

Hazard Manufacturing Company, Wilkes-Barre, Pa., resigned on August 1 to become president of the Connecticut Electric Steel Company, Inc. Mr. Willson was born at Baltimore and received his early education in the public schools of that city. In 1905 he was graduated from the Baltimore Polytechnic Institute and in 1908 graduated from Lehigh University with the degree of electrical engineer. During his school days he was engaged in railway engineering and construction work with the Westinghouse Electric & Manufacturing Company. Upon leaving school he went with the Hazard Manufacturing Company, at the Wilkes-Barre office, in charge of electrical and chemical testing. In July, 1911, he entered the sales department as sales engineer in charge of railroad work, with offices in New York City, which position he held until August 1. In his new position Mr. Willson has headquarters at 50 Church street, New York, but will shortly remove his office to Hartford, Conn., at which point the foundry is located.

Railway Structures

The Chicago, Milwaukee & St. Paul has commenced the construction of new terminal facilities to cost about $65,000, at South Beloit, Ill. The work includes the laying of additional yard tracks, the construction of a three or four stall engine house, with an 80-ft. turntable, a 43-ft. cinder pit, a coaling plant, a power house, 18 ft. by 32 ft., and a water tank. Grading at this point was begun some time ago.

The Chicago, Milwaukee & St. Paul contemplates the construction of terminal facilities at a cost of about $614,000 at Atkins, Iowa. The improvements will include a 26-stall roundhouse, 90-ft turntable, 154-ft. cinder pit, a coal handling plant, a power house 50 ft. by 80 ft., a blacksmith and machine shop 50 ft. by 90 ft., a storehouse 50 ft. by 100 ft., an ice house and other buildings, as well as a modern yard for handling increased traffic.

The New York, New Haven & Hartford will ask for bids as soon as plans are completed for the construction of a roundhouse, also a shop and an office building at White Street yard, Danbury, Conn. The buildings are to be of frame construction with terra cotta fire wall. The roundhouse will contain eight 95-ft. stalls; the shop is to be one story high, 48 ft. by 100 ft., and the office building is to be two stories high, 42 ft. 6 in. wide by 49 ft. 8 in. long. The improvements will cost about $65,000. In addition there will be a boiler and generator room, 48 ft. by 48 ft.; a storeroom, 36 ft. by 48 ft., with an oil storage system.

The Chicago, Milwaukee & St. Paul has started the construction of extensive terminal facilities at North McGregor, Ia., including a 22-stall roundhouse, a 90-ft. turntable, a 100,000-gal. water tank, a 154-ft. cinder pit, a sand house, a coaling station, a power house, 50 ft. by 63 ft., a blacksmith and machine shop, 40 ft. by 60 ft., a car repair building, 40 ft. by 80 ft., and an entirely new yard layout, involving 15 miles of track. The project also involves an extensive channel change of Giard creek and the raising of the yards above the flood level. Aside from part of the grading contract, which has been awarded to Morris Shephard & Dougherty, St. Paul, Minn., all of the work is to be done by company forces.

Trade Publications

Gurney Ball Bearings is the title of a 38-page catalogue issued by the Gurney Ball Bearing Company at Jamestown, N. Y., dealing exclusively with data and information pertaining to the different types of ball bearings manufactured by this company together with their mounting and care.

Belt Pulleys, a paper by Charles A. Brimley, president of the American Pulley Company, and read before the Engineers' Club of Philadelphia, June 20, 1916, is published in a pamphlet recently issued by the American Pulley Company. This paper is presented to fix the attention of engineers on pulleys for transmission of power by belt, and to point out that there is more in the selection of pulleys of the proper type than has been commonly supposed.

Typical I-T-E Circuit Breaker Installations, a 352-page book issued by the Cutter Electrical & Manufacturing Company, Philadelphia, Pa., has been prepared, with the old adage in mind, "seeing is believing." Illustrations are relied upon rather than intricate technical descriptions to suggest the wide range of I-T-E circuit breaker installations, although in the case of certain notable plants, such engineering data have been added as will be of special interest and value to electrical engineers contemplating or having in hand work of a similar character.

One Hundred Condulet Suggestions is the title of a little book issued by the Crouse-Hinds Company, Syracuse, N. Y., showing photographic reproductions of condulet installations with a pictorial index of the condulets and condulet accessories used. The prime object in publishing "Condulet Suggestions" is to illustrate the fact that no matter what form of conduit outlet is required, there is a type of condulet that exactly meets it. The pictorial index is alphabetically arranged and shows enlarged and individual views with descriptions of condulet and condulet accessories used in the illustrations shown on the other pages of the book.

Portable Direct Reading Bond Testers is the title of Bulletin No. 200 for May, 1916, issued by the Roller-Smith Company, 233 Broadway, New York. The bulletin describes the Roller-Smith direct reading bond tester which was designed many years ago for testing the bonds which electrically connect the rails of practically all electric railway systems. The bulletin describes the application of the tester and also contains a complete description of both the standard sensibility and the high sensibility types. The standard type is light and compact and shows the resistance of the bond under test on the scale direct without computation and is operated on the current nominally in the rail and readings can easily be taken with a single observer. The high sensibility type, in appearance and operating principle, is identical with the standard sensibility type but the weight is a few pounds greater and the sensibility very much enhanced. The instrument is intended for use where current in the rail is comparatively feeble.

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Edward Wray

The many friends of Edward Wray will be interested to know that he has resigned from the *Railway Electrical Engineer* to become associated with the Sangamo Electric Company of Springfield, Ill. The announcement appears on another page.

Mr. Wray has been intimately associated with the *Railway Electrical Engineer* since its organization back in 1909 and, as president of the Wray Publishing Company of Chicago, was its sole owner from 1910 until it was purchased by the Simmons-Boardman Publishing Company in 1915.

A description of the early days of the paper and of Mr. Wray's energetic and persevering work in developing it would make a long story in itself. Suffice to say that his enthusiastic devotion to the magazine and to the Association of Railway Electrical Engineers has been a considerable factor in making for the success of both the publication and the association. He has always worked with and for the association and will undoubtedly continue to do so. It is also true that he personally has always worked with and for the individual members of the association and for that reason he has made a host of friends among the electrical men of the steam railroads in the United States and Canada.

We know we are voicing the thought of his many friends when we wish him God speed and every good wish in his new work.

Practical Stunt Competition

On page 441 of the August issue of the *Railway Electrical Engineer* we announced that a prize of ten dollars would be awarded for the best article and a prize of five dollars for the next best article describing a practical stunt or device which has proved of value in railroad operating or maintenance practice.

This competition closed October 1, 1916, and on another page in this issue will be found the two prize winning articles. The first prize has been awarded to Charles W. T. Stuart who is an electrician with the Pennsylvania at Philadelphia, Pa. Mr. Stuart describes and illustrates a hand press for removing ball bearings from axle generator shafts and also for removing shafts from armatures. The second prize has been awarded to E. W. Jansen, electrical engineer, Illinois Central at Chicago, who describes a method of installing an emergency double throw switch for throwing the electric bell circuit on business cars over on the car storage battery when the dry battery regularly used for the purpose, has failed en route.

Many other practical stunts were received, some of them so good that it was difficult for the judges to choose which ones should be given first and second place. These other stunts will be described in subsequent issues and, as originally announced, will be paid for at our regular rate. We are gratified at the interest taken in this competition and hope that it will demonstrate to our readers the value of sending in descriptions of such practical stunts and kinks; this obviously being the most practical way for exchanging such ideas.

Attention is called to the fact that we have discontinued the policy of paying only one dollar each for such articles. In the future they will be paid for according to the space taken and their practical value. We hope that this will be an added incentive for every one to take an active interest in the Practical Stunt columns and to regularly send in ideas of this nature.

Some Interesting Data

The report of the Committee on Data and Information, submitted at this year's convention of the Association of Railway Electrical Engineers, printed elsewhere in this issue, represents a tremendous amount of information presented in understandable form. It is the most complete of any report so far submitted by this committee and as it includes around two-thirds of the total railroad mileage of the country, it may be considered as entirely representative of the electrical equipment installed on steam railroads. It should be noted, however, that the section covering motors does not include those applied to cranes, coaling stations, water tanks, etc., along the line, but simply covers motors in use in shops.

Both the committee and the association are to be highly commended for the good work they have done in compiling this report. Further, the work on the part of individual members should not be overlooked as it is only by their close co-operation that such complete data can be secured.

It is to be hoped that this committee will be continued in the future as it has been in the past, with the idea of making its annual report a complete summary of all the electrical apparatus in use in this, one of the greatest of industrial fields. After the information on their respective systems is once made up by the individual members, it should be easily possible for them to keep it up-to-date without great effort, as in practically every case it is a simple matter to obtain figures showing additions to equipment throughout the year.

One of the greatest advantages of such a report as this lies in the fact that it gives to the individual members data covering their respective systems, which data would not, in many cases, otherwise be compiled. It also provides for the use of numbers, a comparison with other roads as to costs, etc., which will enable them to determine whether the methods employed on their own road are producing maximum efficiency or whether they can be modified to advantage. This is an important factor to be considered in keeping this data up to the minute.

Car Lighting Clubs

A good, live, well attended car lighting club should be located in every large railroad center in the United States and Canada. Such a club would have among its members all railroad men and supply men in the city who are interested in electric car lighting and would do a great deal of good because such men would regularly come together to exchange ideas and thereby become better acquainted. Such meetings could very well be taken up by talks on car lighting subjects, such as battery and generator maintenance, descriptions of various types of apparatus, etc., these talks to be given by the railroad men themselves and by the manufacturers' representatives. It is usually a simple matter to find some place in which to hold the meetings because the higher railroad officers, recognizing the value of such a club, will gladly arrange to provide a room in a centrally located terminal station, or office building or, as is being done in one case, arrange to have the meetings held in a convenient passenger coach.

An item in our news columns this month describes the organization of a new car lighting club in Boston, Mass. This club expects to have a membership of at least 75, and will hold regular bi-monthly meetings in a passenger coach in the North Central station. The organization of this association speaks well for the enterprise of the Boston car lighting men and as the primary object of the association is to enable such men to get together occasionally to talk over matters concerning their work and to hear lectures on car lighting subjects, it is to the best advantage of every car lighting man in Boston to become a member at once and to regularly attend all meetings.

Car lighting clubs or associations have been organized in Chicago and New York for some time and both of these clubs have a large membership and are doing a good work. Other large railroad centers should fall in line with this movement and organize their car lighting clubs without delay. There certainly should be one in each of the following cities: Philadelphia, Baltimore, Pittsburgh, St. Louis, New Orleans, Kansas City, St. Paul, Minneapolis, Denver, San Francisco, Portland and Seattle. Which one of these cities will be the first to organize a car lighting club? The *Railway Electrical Engineer* will gladly furnish all information desired regarding the necessary procedure in organizing such a club and will be pleased to furnish suggested by-laws, constitutions, etc., on request. We will also be glad to devote a certain amount of space each month to the activities of these clubs. It is suggested that such information be mailed to the editor soon after each meeting. We would be glad to hear from any club or car lighting association that we have not mentioned, as, to our knowledge, the ones in New York, Chicago and Boston are the only ones in existence.

The Work of the Association of Railway Electrical Engineers

When the Association of Railway Electrical Engineers came into existence nine years ago under the original name of the Association of Car Lighting Engineers, the electrical departments of the various roads were mainly confined in their activities to the design, installation and maintenance of car lighting equipments. It is true that there was a considerable amount of shop-motor, terminal lighting and power equipment in use at the time but car lighting was undoubtedly the predominating factor.

The past seven or eight years, however, have witnessed a remarkable change in the extensive application of electricity in railroad service, including electric traction, car lighting, shop and other power, arc welding, illumination, etc. The railroad shop today that is not equipped for individual or group motor drive of all power operated tools is decidedly antiquated, and the railroad shop, terminal, or classification yard, which is not equipped with an effective system of illumination is recognized as an element of danger to the employee, and of ineffciency to the railroad.

As the application of electricity in railroad operation has progressed so has the activity of the Association of Railway Electrical Engineers. In the early days its name was changed so as to more correctly indicate the activity of the association and every year has seen a broadening in the scope of the work of the various committees.

The association has prepared a specification for rubber covered wire which is generally regarded as standard. This specification has been revised from year to year so as to make it more comprehensive and to keep it in line with recent developments, and it is a fitting testimonial to the work of this committee to note that this specification has been copied, either in part or in its entirety, by numerous societies, associations and operating companies.

In standardizing car lighting equipment, the association has done a work of incalculable value to the service. Practically all recommendations of the A. R. E. E. committee on standards have been adopted verbatim by the M. C. B. association and the interchangeability of car lighting equipment has been generally adhered to by all railroads and manufacturers.

The A. R. E. E. committee on ball bearings for axle lighting generators selected one size of bearing which was best suited for this service and practically, without exception, this size of bearing has been universally adopted. When one thinks of the chaotic condition which would have resulted had every individual manufacturer selected the size of bearing for his machine, it is evident that the present situation, with but one standard bearing for all sizes and makes of machines, is a compliment to the work of the association.

The association has also inaugurated a movement to standardize bearing sizes for electric motors. This work is well under way and another year will undoubtedly see some tangible results which will be of far-reaching importance, affecting the entire electrical industry.

The association was again of great service to its members when it went on record as favoring the lumen basis for rating incandescent lamps at its last semi-annual convention. By so doing, it was the first association to officially adopt this unit as a standard, thereby blazing the way for the other electrical associations.

This year's report on shop practice is especially comprehensive and the completeness with which the various sections under this report are compiled simply proves that the members of the association have outgrown the strictly electric car lighting field and have broadened out to consider all phases of the application of electricity to steam railroads. It is especially gratifying to note the thoroughness with which the sub-committee on electric welding handled its subject. Electric arc welding is bound to take an important place in railroad maintenance work and the report of the committee this year will do a great deal to familiarize railroad electrical engineers with the art and its application and uses.

The report of the committee on illumination this year is also an example of the broad and comprehensive work the members of our association are capable of doing. The report of the sub-committee on yard lighting is very complete and will undoubtedly be regarded as an authority in the field of illuminating engineering on the subject in question.

The investigation and study of car and train lighting problems are a most important part of the association's work, but only a part. This subject must continue to receive a great deal of attention, but the association is big enough to broaden out and cover other subjects of equal interest to the steam railroad electrical men, something it must do if it is to grow and thereby continue to demand the attention and support of the higher railroad officers. Some of these other subjects are now receiving the serious attention of the association, but others are not, and unquestionably all should be.

The time is at hand when the association can profitably still further broaden its work and investigations. Take, for example, the generation of power for steam railroads. This important field, including steam, electric, compressed air, and gas power, can well be handled by committees of the association, the members of which, with few exceptions, are perhaps better qualified to handle the subject than any one else among steam railroad men. Some excellent papers on this subject have been read at the conventions, but the matter of power and power plants for steam railroads should be followed up by a regular standing committee.

The growing importance of electric traction on steam railroads, forcibly brought to our attention by the remarkable success of the Norfolk & Western and the Chicago, Milwaukee & St. Paul electrifications undoubtedly makes it desirable that our associations appoint a representative committee to thoroughly go into all phases of this subject, including the choice of systems, the design and construction of catenary and third-rail systems, the design, operation and maintenance of electric locomotives, with similar information regarding motor cars such as used in the suburban service of several of the railroads. The Association of Railway Electrical Engineers, working with the manufacturers, can take the lead in analyzing and solving the various problems in connection with electrification as applied to steam railroads.

Our association is young, but it has the proper spirit and it certainly will not overlook an opportunity to develop and classify authoritative data on the subjects mentioned. There is no better time than the present for the association to assert itself, and do the work which rightfully belongs to it. By its very name the Association of Railway Electrical Engineers assumes the responsibility of guiding its members, among whom are the electrical engineers of the steam railroads in the United States, in the choice of standards and other equipment for every feasible application of electricity in steam railroad practice and, with few exceptions, this responsibility has been well met. It should not be said that the members of the Association of Railway Electrical Engineers must go to other associations for information necessary to its members. Its members are big enough and broad enough and skillful enough to work out their own problems and to obtain the information they require.

So with the common purpose of pushing the Association of Railway Electrical Engineers to a still higher position in the estimation of the higher railroad officers, and of making it one of the biggest and most important railroad associations in the country, let us discard all personal likes and dislikes and work together to broaden out its work, thereby increasing its prestige and usefulness.

Ninth Annual Convention

A. R. E. E.

October 31-November 3, Hotel La Salle, Chicago

Committee Reports†

The first meeting will be called to order at 10 o'clock a. m., Tuesday, October 31, in the Red Room on the 19th floor of the Hotel La Salle, Chicago, Ill. The morning session will be taken up by the address of the president, the report of the secretary-treasurer, unfinished business and new business. The first committee report will be presented in the afternoon session on Tuesday, which commences at 2 o'clock. On the remaining days of the convention, Wednesday, Thursday and Friday, the morning session will start at 9 o'clock and the afternoon session at 2 o'clock.

Reciprocal Relations*

Joseph A. Andreucetti, Chicago & North Western, chairman; L. S. Billau, Baltimore & Ohio; J. R. Sloan, Pennsylvania.

Loose Leaf Binders*

J. R. Sloan, Pennsylvania, chairman; J. L. Minick, Pennsylvania; T. V. Buckwalter, Pennsylvania.

Anti-Friction Bearings for Motor Equipment

Your committee, to establish sizes of ball or roller bearings for motor equipment, has held a number of meetings and conferences on this subject. Early in its deliberation it was found that to accomplish the purpose for which this committee was formed, it would be absolutely necessary to confer and work in conjunction with the manufacturers of motors. In attempting to carry out this plan, your committee found that it was impracticable to deal with the manufacturers individually on this subject; but after conferences with manufacturers of motors it was determined that the proposition would have to be worked out between the committee of the Electric Power Club representing the motor interests, and the committee of this association.

Your committee has been in conference with the committee on standardization of the Electric Power Club detailed for this work, but to date no tangible or constructive work has been accomplished. It is apparent that work of this kind, involving the changing of present motor designs and standards, must necessarily proceed slowly and with careful deliberation so that no hasty or inconsistent recommendations will be made.

Your committee feels that it has made a good start in accomplishing the end for which it was formulated, and has great hope that it may be able to furnish more definite information at the next semi-annual meeting.

Your committee will offer discussion and show data accumulated on this subject when this progress report is read.

Committee: C. J. Causland, Pennsylvania, chairman; C. R. Gilman, Chicago, Milwaukee & St. Paul; M. S. Meloy, New York Central; A. J. Farrelly, Chicago & North Western; J. C. McElree, Illinois Central; E. Wanamaker, Chicago, Rock Island & Pacific; W. O. Doud, consulting engineer, Chicago; L. Gazin, Atchison, Topeka & Santa Fe.; J. A. Shaw, Canadian Pacific; W. A. Hancock, Central of Georgia.

Crane, Turntable and Transfer Table Motors

Your committee herewith submits the same report that was submitted to the semi-annual meeting.

The committee held meetings on February 12 and March 24. It was decided that the first thing to consider was taking up with the different motor manufacturers the question of construction along the following lines:

1. Motor rating: Standard motor speed of 600, 750 and 900 R.P.M., corresponding to full load speed of D.C. motors, and synchronous speed for A.C. motors, except in case of the 750 R.P.M., 60 cycle, A.C. motor. For A.C. motors in intermittent service, we suggest 1,200 R.P.M., but not for general use
2. Temperature rating on a basis of 50 degrees Centigrade rise by the thermometer method for open type motors, and 50 degrees rise for enclosed type motors on a one-half hour run at full load.
3. Torque rating on starting should be from 7 to 10 times the full load torque.
4. Standard dimensions for D.C. motors on—(a) Height of shaft above motor base, (b) Bolt hole dimension and spacing in four directions, (c) Shaft diameter and shaft extension outside of the bearing, (d) Keys and keyways.
5. Standard dimensions for D.C. motors on—(a) Height of shaft above motor base, (b) Bolt hole dimension and spacing in four directions, (c) Shaft diameter and shaft extension outside of the bearing, (d) Keys and keyways.
6. Standard sizes of anti-friction bearings for various sizes of motors used on traveling cranes. We suggest that this standardization be established by collaboration with the motor bearing committee of the Association of Railway Electrical Engineers. The association invites the co-operation of the Electric Power Club in bringing about these standards.

The sub-committee appointed to take this question up with the Power Club, representing different manufacturers at their meeting held at Hot Springs, May 1 and 2, reports that the Power Club representatives seemed very friendly towards the proposition of standardizing on crane motors, and the question has been referred to the committee on motor applications, which, I understand, they will take into consideration and report at a later date relative to a joint meeting with our committee. The committee decided that before taking the question up with the crane manufacturers they would wait for some definite information from the motor manufacturers.

Since the above report was made, your committee has been in communication with the chairman of the Motor Application Committee of the Electric Power Club, and the suggestion has been made by this committee that the matter of standardization of crane, turntable and transfer table motors be also taken up with the electrical engineers of steel plants and also with a committee of crane builders. Progress, however, in obtaining co-operation of the last two named committees has been slow, but it is anticipated that we will be able to get all the people interested in this work together shortly. The work of this committee requires co-operation of all users of this class of equipment. The work of this committee must naturally proceed slowly as it involves changes in present standards that will require some time to determine. Your committee hopes to be able to present more definite data at the next semi-annual meeting, and invites suggestions and discussions on this work. Your committee is also of the opinion that it would be a good plan to consolidate this committee with the committee to establish sizes of ball or roller bearings for motor equipment.

Committee: H. C. Meloy, New York Central, chairman;

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*This committee will make a verbal report.

†The Association of Railway Electrical Engineers assumes no responsibility for the individual views of its members on the various topics and disavows any action taken on the various subjects except such action as is taken in due course and accordance with the constitution.—J. A. Andreucetti, Sec.-Treas. Association Railway Electrical Engineers.

C. J. Causland, Pennsylvania; J. E. Gardner, Chicago, Burlington & Quincy; A. J. Farrelly, Chicago & North Western; P. L. Battey, Arnold Company; T. V. Buckwalter, Pennsylvania.

Headlights*

J. L. Minick, Pennsylvania, chairman; C. R. Sugg, Atlantic Coast Line; J. J. Hack, Southern Pacific; E. W. Jansen, Illinois Central; H. R. Pennington, Chicago, Rock Island & Pacific.

Metal Conduit Specifications*

J. L. Minick, Pennsylvania, chairman; J. A. Andreucetti, Chicago & North Western; A. L. Chapin, Illinois Central; A. S. Schuman; C. J. Causland, Pennsylvania; F. J. Hill, Michigan Central.

Data and Information

The report of your committee this year is somewhat more comprehensive and a greater number of roads are listed than in any of its previous reports. The scope has been broadened so as to include lifting magnets, magnetic chucks and arc welding equipment, but in general the same outline of information used in past years has been followed with the result that we have a more or less reliable basis of comparison which shows the trend of the general practice in electrical equipment on railroads.

Another interesting feature in this year's report is that part pertaining to car lighting generator bearing failures, and bearing maintenance. A very large percentage of the ball bearing failures are shown to be due to improper mounting rather than to faults in the bearing itself.

The large table No. 1 contains much information on the individual equipment of each road, and a careful analysis of certain classes of data will undoubtedly yield interesting facts; your committee will only attempt, however, to point out the salient features.

Probably the most interesting data is that of car lighting costs, and it is a significant fact that most of the costs are obviously based on carefully kept records instead of being rough estimates as in previous reports. It will be noted that for the most part these costs run about $2.00 per 1,000 car miles. The greater accuracy of the cost data this year is undoubtedly due to the fact that this information was requested to be in accordance with the accounting methods of the Interstate Commerce Commission.

In belt mileage there seems to be the usual wide discrepancy in values. This is probably due to different operating conditions, variation in care of belt maintenance and also to the degree of care with which belt records are kept.

Referring to the comparison in Table No. 2 it will be noted that marked progress has been made during the past six years in certain lines, while other classes of equipment have actually shown a loss. The increase in electric lighted cars from 11,017 in 1911 to 20,841 in 1916 is especially interesting. It should be pointed out, however, that this data simply represents the total amount of equipment reported to the committee. In making comparison of totals the total mileage of the roads reporting should be considered.

The number of ball bearing generators in service has shown a substantial increase over the past year. Gasoline engine motor cars, on the other hand, show a decline.

In electric headlight equipment the data would indicate that practically all new equipment has been of the incandescent type, as the number of arcs is about the same as last year while the incandescents have trebled.

The number of a. c. arc lamps is about the same as in 1914, and considering the mileage of roads reporting this represents a great decrease in the use of arcs. The 1915 figure is probably in error. The lamp data shows that although there has been a big increase in the number of 100 vacuum type mazdas, there has been no increase in larger sizes of vacuum type. The gas filled lamps, on the other hand, show a wonderful increase in all sizes.

The section covering motors is more complete than has been the case in any previous report. Fifty-six roads are included, the aggregate mileage of these roads being about 65 per cent of the total for the country. This is a considerable increase over the 1915 report, in which 37 roads, with an aggregate mileage of slightly less than 50 per cent of the total for the country, were included.

Of the motors reported, those using direct current represent 52.4 per cent in number and 47.4 per cent of total horsepower, the average horsepower of the direct current motors being 15.82. Three-phase motors constitute 39.9 per cent of the total number and 45.3 per cent of the total horsepower reported. The average horsepower of the three-phase a. c. motors is 19.8.

TABLE II

Electrical Equipment in U. S. and Canada

	Totals reported					
	1911	1912	1914		1915	1916
Number of roads reporting	57	58	67		78	76
Electric lighted cars	11,017	13,115	18,936		18,793	20,841
Cells, lead battery	202,744	222,989	259,842		307,147	292,568
Cells, nickel iron	.....	4,855	31,883		36,653	64,343
Straight storage cars	1,372	2,078	2,707		24,042	3,245
Head-end generator sets	192	291	273		273	335
Axle generator cars, 60 and 30 volts	5,900	7,198	12,458	60 volts	232	320
				30 "	13,039	6,186
				24 "	577	690
Ball bearing generators	.....	.....	.....		1,652	5,417
Water for Batteries—						
Distilled water	.....	.....	116		248	237
Tap water	.....	.....	57		54	69
Pipe condensation	.....	.....	15		17	15
Filtered water	.....	.....	10		1	5
Industrial Trucks—						
Baggage handling	.....	.....	187		178	218
Freight house	.....	.....	124		132	148
Battery and commissary	.....	.....	14		14	13
Electric tractors	.....	.....	1		1	2
Shop trucks	.....	.....	45		48	61
Motor Cars Operated on Rails for Passenger Traffic—						
Straight gasoline cars	.....	.....	197		184	112
Gas electric cars	.....	.....	30		18	32
Electric Headlights—						
Arc	.....	.....	12,432		16,446	16,306
Incandescent	.....	.....	932		1,287	3,510
Lamps—						
Arc lamps, a. c.	.....	.....	9,600		4,206	9,060
Arc lamps, d. c.	.....	.....	8,096		3,287	4,350
Magnetite arc lamps	.....	.....	1,429		1,381	2,307
Flaming arc lamps	.....	.....	1,252		1,726	477
Cooper Hewitt's	.....	.....	1,516		2,127	936
Quartz tube	.....	.....	55		42	40
Incandescent Lamps, Vacuum Type—						
100 watt Mazda	.....	.....	.....		15,677	31,703
150 watt Mazda	.....	.....	9,030		10,729	8,863
250 watt Mazda	.....	.....	11,205		12,038	8,977
400 watt Mazda	.....	.....	1,576		2,495	1,496
500 watt Mazda	.....	.....	734		2,318	2,076
Incandescent Lamps, Gas-filled Type—						
100 watt Mazda	.....	.....	.....		356	9,200
200 watt Mazda	.....	.....	.....		370	8,898
300 watt Mazda	.....	.....	.....		259	1,327
400 watt Mazda	.....	.....	.....		340	2,292
500 watt Mazda	.....	.....	.....		86	1,085
750 watt Mazda	.....	.....	.....		211	521
1,000 watt Mazda	.....	.....	.....		112	189
Generators, a. c. (Total number)	.....	.....	264		433	325
Total hp. a. c. generators	.....	.....	123,401		139,541	201,883
Generators, d. c. (Total number)	.....	.....	566		772	639
Total hp. d. c. generators	.....	.....	65,077		81,272	70,250

The grand total of all motors reported this year amounts to 16,992, representing a total horsepower of 297,160. This is a very considerable increase over last year's report, in which 11,546 motors were shown, totaling 183,077 horsepower.

It is gratifying to note that a number of roads not heretofore reporting have done so this year, the number sending in new reports being considerably greater than those failing to report this year.

It is the belief of your committee that the additional data included in this report is of considerable value and that the widening of the scope of data included will make the report worth more, not only to the association but to the individual members contributing.

Committee: Edward Wray, *Railway Electrical Engineer*, chairman; C. J. Causland, Pennsylvania; J. E. Gardner, Chicago, Burlington & Quincy; B. F. Bilsland, General Electric Company; G. W. Cravens, C. & C. Electric Company; J. R. Sloan, Pennsylvania; E. W. Jansen, Illinois Central.

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*This committee will make a verbal report.

TABLE III.—NUMBER OF DIRECT CURRENT MOTORS

	SIZE OF MOTORS																									
	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	35	40	50	75	100	125	150	200	225	250	300	Total motors	Total hp.
Atchison, Topeka & Santa Fe System	...	...	...	3	...	5	15	25	21	26	19	16	10	3	1	1	2	1	...	...	...	...	...	...	...	148	1,795½
Atlanta, Birmingham & Atlantic	...	...	...	...	...	1	...	...	1	1	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...	7	109½
Atlantic Coast Line	1	...	1	3	2	8	20	26	22	23	17	8	17	1	4	2	5	...	3	...	...	...	...	...	...	163	2,247½
Baltimore & Ohio	15	7	...	10	12	9	14	34	8	54	25	60	41	25	17	17	21	17	11	4	...	2	...	...	...	a407	a11,212¼
Bangor & Aroostook	...	1	...	...	...	2	1	5	5	1	1	1	1	...	1	...	...	...	...	...	...	...	...	...	...	19	175
Buffalo, Rochester & Pittsburgh	...	1	...	...	...	2	4	16	9	10	15	6	2	10	2	2	3	...	...	1	...	...	...	...	...	83	1,384
Canadian Pacific	...	4	2	1	...	1	5	10	2	12	18	5	1	6	6	...	...	...	...	...	...	...	...	...	...	73	991½
Central of Georgia	1	...	...	...	...	1	...	2	3	...	2	...	1	...	...	...	...	...	...	...	...	...	...	...	...	10	89¾
Central Railroad of New Jersey	9	3	...	6	...	10	23	60	20	37	25	11	15	12	2	5	8	1	...	...	...	...	...	...	...	247	2,993¾
Chicago & Alton	4	...	1	...	1	1	13	35	11	23	28	10	19	...	1	4	7	2	...	...	...	...	...	2	...	162	2,821½
Chicago & Eastern Illinois	...	...	...	...	...	8	...	6	7	12	10	10	8	...	3	...	3	...	...	...	...	...	...	...	...	67	1,023½
Chicago & North Western	12	23	15	6	7	25	27	79	15	78	55	39	46	18	27	10	12	8	2	...	...	...	...	...	...	504	7,499
Chicago & Western Indiana	...	1	...	...	...	...	4	7	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14	65
Chicago, Burlington & Quincy	11	2	...	4	1	17	17	59	31	50	49	15	22	4	15	9	11	1	...	...	...	...	...	...	...	318	4,336½
Chicago Great Western	...	1	2	...	1	...	5	3	13	14	29	15	10	21	5	7	2	5	1	1	...	...	...	...	...	135	3,040¾
Chicago, Indianapolis & Louisville	...	...	...	...	...	1	3	6	...	2	2	1	3	3	...	...	1	...	...	...	...	...	...	...	...	22	326
Chicago, Milwaukee & St. Paul	...	9	1	...	12	13	9	27	19	64	62	46	4	128	4	11	32	4	...	1	...	...	...	...	...	446	9,385¾
Chicago, Rock Island & Pacific	3	...	1	3	4	9	18	28	15	21	38	3	28	9	1	2	16	...	...	...	...	...	...	...	...	199	3,059
Chicago, St. Paul, Minn. & Omaha	...	...	...	1	...	2	6	18	8	10	16	1	5	4	8	...	3	...	...	...	...	...	...	...	...	82	1,208
Cincinnati, Hamilton & Dayton	...	1	...	...	...	1	1	...	6	6	...	4	5	1	1	...	2	2	3	4	...	4	...	...	...	41	2,230½
Cleveland, Cincin., Chic. & St. Louis	...	...	...	3	1	7	17	34	26	32	18	20	17	6	2	5	17	7	...	...	...	...	...	...	...	212	3,674¼
Colorado & Southern	...	1	...	...	...	1	1	6	7	6	10	4	7	1	7	1	1	...	...	...	...	...	...	...	...	53	918
Delaware & Hudson	...	2	...	5	...	17	10	7	9	16	27	11	16	5	1	...	3	6	2	...	...	...	...	...	...	137	2,342½
Delaware, Lackawanna & Western	5	7	1	31	1	25	33	69	33	34	16	19	20	22	1	1	7	6	2	...	...	...	...	...	...	333	3,974¼
Denver & Rio Grande	...	...	...	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	16
El Paso & Southwestern	3	...	...	...	...	2	2	4	2	6	6	2	2	9	3	...	2	...	...	...	...	...	...	...	...	43	760¾
Florida East Coast	...	...	...	...	...	...	2	5	2	7	...	2	3	...	...	...	...	...	...	...	...	...	...	...	...	21	231
Grand Rapids & Indiana	1	...	...	2	...	1	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	29¼
Great Northern	1	2	4	2	...	7	3	...	...	8	1	1	...	...	...	...	...	2	...	...	...	...	...	...	...	31	294¼
Illinois Central	...	2	...	...	1	4	5	4	4	11	12	3	10	...	2	3	9	...	...	...	...	...	...	...	...	70	1,315¼
Kansas City, Mexico & Orient	...	...	...	...	...	...	3	...	6	...	1	...	5	...	1	3	3	2	...	...	...	...	...	...	...	24	649
Louisville & Nashville	...	...	6	11	3	2	9	22	32	30	73	20	6	29	7	2	26	7	3	2	...	...	...	...	...	290	5,915¼
Minneapolis, St. Paul & S. S. Marie	...	...	...	1	1	1	16	19	26	13	24	20	11	...	4	9	4	...	...	...	...	...	...	...	...	149	2,207¼
Nashville, Chattanooga & St. Louis	...	...	...	...	...	...	...	...	...	...	...	...	4	...	1	...	...	...	...	...	...	...	...	...	...	5	135
New York Central (Lines West)	2	6	...	6	6	12	28	41	45	58	56	35	27	12	7	1	6	...	4	...	...	...	...	...	...	352	4,807½
New York, Ontario & Western	...	...	...	...	...	7	9	18	8	27	21	8	7	1	1	...	4	...	...	...	...	...	...	...	...	111	1,376
Pennsylvania	114	36	12	204	23	126	147	293	176	284	120	273	118	49	35	61	70	35	11	4	2	...	...	1	...	2,194	30,226¼
Pennsylvania Lines West	1	...	1	9	5	16	18	35	40	66	35	41	27	7	14	8	12	18	...	...	...	...	...	...	...	353	6,227¼
Philadelphia & Reading	5	7	4	3	2	5	39	25	51	35	26	33	1	5	...	10	20	4	...	...	...	...	...	...	...	b277	b4,822¾
St. Louis & San Francisco	...	4	...	1	...	9	7	8	3	8	3	1	5	2	...	...	3	...	...	...	...	...	...	...	...	54	584½
Seaboard Air Line	...	1	...	...	...	3	9	11	4	10	12	1	7	...	...	1	2	2	1	...	...	...	...	...	...	64	983½
Southern	...	...	...	...	...	...	25	16	13	18	18	27	6	...	7	...	9	6	4	...	...	...	...	...	...	149	2,937½
Southern Pacific	5	1	2	3	...	10	24	31	34	36	23	7	21	3	2	2	10	1	...	...	...	...	...	...	...	215	2,693¼
Texas & Pacific	2	3	...	3	...	2	4	5	2	3	...	...	3	...	1	1	4	1	1	1	1	...	...	...	...	37	891
Texas City Terminal	...	...	...	1	...	1	9	2	3	2	4	15	...	1	1	...	...	...	1	...	...	...	...	...	...	40	607½
Union Pacific	5	2	3	5	5	20	41	40	38	24	38	18	7	...	1	...	13	1	2	...	1	...	...	...	...	264	3,118¾
Oregon Short Line	1	1	1	1	...	5	9	16	20	22	11	7	5	1	...	3	...	...	...	...	...	...	...	...	...	103	1,069½
Oregon-Wash'gton R. R. & Nav. Co.	...	...	...	1	...	10	4	13	8	11	7	5	7	...	3	...	3	...	3	...	...	...	...	...	...	75	1,203
Wabash Pittsburgh Terminal	...	...	...	...	2	2	2	4	1	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16	100
Western Maryland	...	...	...	2	...	5	6	10	24	11	7	4	1	2	...	...	1	...	...	...	...	...	...	...	...	73	690
Western Pacific	...	...	...	...	...	...	...	...	1	...	...	1	...	...	2	...	...	...	...	...	...	...	...	...	...	4	97½
Totals	201	128	57	332	90	416	667	1,184	835	1,227	985	830	582	401	201	181	357	139	54	18	4	6	...	3	...	*8,904	*140,892

Average size of motor, 15.82 hp.

(a) Includes 4 motors of 350 hp. each. (b) Includes 2 motors of 450 hp. each. (*) Includes the 6 foregoing motors of total 2,300 hp.

TABLE IV.—NUMBER OF SINGLE PHASE A. C. MOTORS

SIZE OF MOTORS

	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	35	40	50	75	100	125	150	200	225	250	300	Total motors	Total hp.
Atlantic Coast Line	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	5
Buffalo, Rochester & Pittsburgh	...	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	5½
Canadian Pacific	3	1	1	9	1	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	19	20¼
Central Railroad of New Jersey	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	4¼
Chicago & Alton	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	¼
Chicago & East Illinois	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	10
Chicago & Western Indiana	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	2
Chicago, Burlington & Quincy	1	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	9¼
Chicago, Indianapolis & Louisville	...	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	4
Chicago, Rock Island & Pacific	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	2
Delaware & Hudson	6	1	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	8	37
Delaware, Lackawanna & Western	1	1	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	30¾
Denver & Rio Grande	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	2	50
Grand Rapids & Indiana	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	2
Illinois Central	2	1	...	...	2	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	13
New York Central (Lines West)	...	...	1	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	9¼
Pennsylvania	8	3	5	1	7	3	2	2	2	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	35	104
St. Louis & San Francisco	4	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	2¾
Oregon Short Line	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	½
Vandalia	1	3	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	4
Western Maryland	1	1	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	2¾
Western Pacific	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	½
Totals	28	15	7	19	12	11	6	4	4	1	2	...	4	...	1	...	...	...	...	...	...	...	...	...	...	114	319

Average size of motor, 2.79 hp.

TABLE V.—NUMBER OF TWO-PHASE A. C. MOTORS

SIZE OF MOTORS

	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	35	40	50	75	100	125	150	200	225	250	300	Total motors	Total hp.
Atlantic Coast Line	2	...	...	3	...	10	7	15	13	23	21	9	3	18	...	...	3	2	1	...	...	...	...	...	...	130	1,957
Baltimore & Ohio	...	...	...	...	...	...	...	...	...	...	2	3	...	...	...	...	...	...	...	...	...	...	...	...	...	5	90
Buffalo, Rochester & Pittsburgh	...	...	...	...	...	3	2	6	2	4	2	6	...	2	...	...	...	...	...	1	...	...	...	...	...	28	432
Central of Georgia	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	2	80
Central Railroad of New Jersey	...	...	...	...	...	...	...	28	...	...	2	1	...	...	...	...	1	...	...	...	...	...	...	...	...	32	240
Chicago & Alton	...	...	...	...	...	...	...	1	...	...	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	5	80
Chicago, Indianapolis & Louisville	...	1	...	...	...	1	...	2	2	...	3	2	2	...	1	...	...	...	1	...	...	...	...	...	...	15	297½
Chicago, Rock Island & Pacific	1	...	...	...	1	1	...	1	1	...	3	...	...	1	2	...	4	...	...	...	...	...	...	...	...	15	361
Chicago, St. Louis, Minn. & Omaha	...	...	...	...	...	...	...	5	5	2	4	...	2	1	...	...	...	...	...	...	...	...	...	...	...	19	222½
Duluth, South Shore & Atlantic	...	...	...	...	...	...	2	...	1	3	6	3	1	...	...	1	1	1	1	...	...	...	...	...	...	20	483½
El Paso & Southwestern	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1	20
Florida East Coast	...	...	...	...	...	...	4	5	1	...	6	1	1	...	...	...	...	...	1	...	1	...	...	...	...	20	429½
Galveston, Harrisburg & San A.	...	...	...	...	...	...	1	...	3	4	1	5	1	...	1	1	1	...	...	...	...	...	...	...	...	18	330½
Kansas City, Mexico & Orient	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	50
New York Central (Lines West)	...	...	...	...	...	...	6	...	5	8	5	6	1	4	...	6	1	...	...	...	...	...	...	...	...	42	765½
New York, Ontario & Western	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	10
Philadelphia & Reading	...	2	...	2	...	2	6	23	22	33	13	17	...	16	...	4	2	1	20	...	...	...	...	...	...	163	3,985
Pennsylvania	9	3	8	8	...	21	25	65	52	133	119	77	12	43	11	21	20	2	5	...	3	...	2	...	...	639	10,869¾
St. Louis & San Francisco	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	30
Seaboard Air Line	...	...	...	...	...	...	...	2	...	...	2	2	1	...	3	...	...	1	...	...	...	...	...	...	...	11	285
Southern Pacific	...	1	3	...	...	...	...	1	3	2	2	1	...	...	...	...	1	...	...	...	...	...	...	...	...	14	150¼
Texas & Pacific	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	15
Vandalia	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	15
Total	12	7	11	13	1	38	53	154	110	213	195	135	25	86	18	35	35	7	29	1	4	...	2	...	...	1,184	21,199

Average size of motor, 17.9 hp.

TABLE VI.—NUMBER OF THREE-PHASE A. C. MOTORS

	SIZE OF MOTORS																									Total motors	Total hp.
	¼	½	¾	1	1¼	2	3	5	7½	10	15	20	25	30	35	40	50	75	100	125	150	200	225	250	300		
Atchison, Topeka & Santa Fe System	...	...	...	...	...	2	3	31	18	32	33	51	16	27	21	6	7	3	...	...	...	...	...	...	...	250	4,898
Atlantic Coast Line	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	5
Baltimore & Ohio	3	2	...	...	...	6	10	10	9	29	68	88	4	26	6	21	11	25	1	...	...	...	...	...	...	319	7,686¼
Bangor & Aroostook	...	...	...	...	...	...	...	2	...	...	2	4	...	1	...	...	...	...	...	...	...	...	...	...	...	9	150
Buffalo, Rochester & Pittsburg	...	...	...	...	...	...	1	1	1	...	...	1	1	...	...	...	...	...	...	1	1	...	...	...	...	7	335½
Canadian Pacific	...	...	...	...	...	7	26	70	15	80	58	65	2	68	5	9	14	20	8	...	...	...	...	...	...	447	9,149½
Central of Georgia	1	...	...	...	...	2	1	4	4	3	3	7	...	4	1	2	...	1	1	...	...	...	...	...	...	34	682¼
Central of New Jersey	...	...	...	...	...	1	1	3	1	8	6	6	...	4	...	4	...	2	...	...	...	...	...	...	...	36	747½
Central of Vermont	...	...	...	...	...	...	1	1	3	2	1	...	3	...	4	...	3	...	...	...	...	...	...	...	...	18	430½
Chicago & Alton	...	...	1	...	...	1	12	11	8	9	8	14	1	4	...	2	...	3	...	...	...	...	...	...	2	76	1,693¾
Chicago & Eastern Illinois	...	...	...	...	...	...	...	2	...	4	1	3	...	2	...	...	1	1	...	...	...	...	...	...	...	14	310
Chicago & North Western	...	5	2	6	...	16	35	44	17	29	19	34	13	12	9	14	9	7	...	...	...	...	...	...	...	271	4,284½
Chicago & Western Indiana	...	...	...	...	...	1	1	3	2	4	5	5	...	...	1	...	1	...	...	...	...	...	...	...	...	23	335
Chicago, Burlington & Quincy	...	...	5	2	...	5	12	33	18	33	32	13	3	18	4	6	5	1	...	...	...	...	...	...	...	190	2,741¾
Chicago Great Western	...	...	...	...	...	...	...	1	...	...	23	2	...	6	1	...	...	1	...	3	...	1	...	...	...	38	1,255
Chicago, Milwaukee & St. Paul	...	...	...	...	...	...	...	...	...	2	3	4	...	...	...	...	...	...	2	...	...	...	...	...	...	11	345
Chicago, Rock Island & Pacific	...	4	...	1	...	3	4	14	10	11	12	11	6	1	27	2	14	...	...	1	...	...	...	...	...	121	2,706
Chicago, St. Paul, Minn. & Omaha	...	...	...	...	1	...	3	6	...	8	5	3	1	2	1	...	2	1	...	...	...	...	...	...	...	33	550¼
Cincinnati, Hamilton & Dayton	...	...	...	...	...	...	...	...	...	...	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	3	60
Cleveland, Cincin., Chic. & St. Louis	...	...	...	...	...	7	16	46	49	33	25	10	10	1	10	1	9	4	1	2	...	...	...	...	...	224	3,334½
Colorado & Southern	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	3	132½
Delaware & Hudson	...	...	...	...	...	12	3	17	5	18	30	15	17	3	8	1	22	3	...	...	...	...	...	...	...	154	3,245½
Delaware, Lackawanna & Western	3	3	2	14	2	12	36	121	85	87	56	63	5	21	1	13	15	15	...	2	1	...	...	...	...	a558	a8,389¾
Denver & Rio Grande	...	...	...	2	...	3	4	9	2	17	14	6	3	4	1	2	18	4	1	...	1	...	...	...	...	91	2,340
Galveston, Harrisburg & San A.	1	4	...	1	...	2	...	6	8	12	10	20	5	4	5	2	4	2	...	...	...	...	...	...	...	86	1,617¼
Grand Rapids & Indiana	...	...	...	1	...	1	2	3	1	2	4	2	3	2	1	...	1	1	...	...	...	...	...	...	...	24	446½
Great Northern	...	...	...	1	3	9	29	32	48	83	92	62	38	12	25	17	26	25	3	...	...	2	2	...	...	509	11,269¾
Illinois Central	...	10	...	17	9	10	61	72	53	75	108	52	12	39	6	8	20	7	6	...	...	...	...	...	...	565	8,528¾
Lake Erie & Western	...	...	...	...	...	...	...	1	1	1	5	1	1	...	...	1	1	...	...	...	...	...	...	...	...	12	232½
Louisville & Nashville	...	...	...	...	...	...	...	1	21	4	13	2	2	...	6	...	2	...	1	...	...	...	...	...	...	52	897½
Michigan Central	...	...	...	29	3	19	20	36	24	16	50	18	18	25	...	...	23	7	...	...	1	...	2	1	...	b295	b7,685¾
Nashville, Chattanooga & St. Louis	...	...	...	...	...	7	1	4	3	3	...	3	2	...	4	...	5	...	...	...	...	...	...	...	...	32	589½
N. Y. Central (Lines West)	...	...	...	2	1	1	16	29	35	30	31	20	17	5	11	10	7	5	...	...	1	2	3	...	1	227	5,235¾
New York, Ontario & Western	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	3
Pennsylvania	12	4	...	7	1	30	43	87	46	77	49	57	7	23	28	17	19	4	14	3	...	4	...	3	1	c539	c12,137¼
Pennsylvania Lines West	1	5	1	5	5	1	13	34	19	37	38	25	19	19	9	4	15	7	7	3	4	...	1	...	...	272	6,503¼
Philadelphia & Reading	...	...	...	...	...	...	...	...	...	...	1	1	...	...	1	...	...	3	2	...	...	...	...	...	...	8	495
St. Louis & San Francisco	4	...	...	3	...	3	...	2	10	13	14	20	2	7	...	...	...	...	...	...	...	...	...	...	...	78	1,095
Seaboard Air Line	2	3	...	1	...	4	13	12	9	14	5	7	17	1	1	...	3	5	1	...	...	...	...	...	...	98	1,647½
Southern	...	...	...	...	...	...	7	12	17	...	24	21	1	...	10	...	15	2	1	...	...	...	...	...	...	110	2,363½
Southern Pacific	14	7	3	14	1	35	34	63	42	59	44	30	7	16	6	1	22	49	4	...	2	1	...	...	...	d455	d9,631½
Texas & Pacific	...	...	...	...	...	...	...	...	...	...	2	1	1	...	1	...	1	1	...	...	...	...	...	...	1	8	535
Texas City Terminal	...	...	...	...	...	...	...	...	...	1	...	1	...	3	...	2	4	1	...	...	...	...	...	...	...	12	475
Union Pacific	3	3	...	1	...	7	12	35	30	13	24	14	7	14	1	3	9	2	...	...	2	...	...	...	1	181	3,173¼
Oregon Short Line	2	2	...	5	...	5	8	12	6	23	9	11	3	2	1	3	4	2	...	...	...	...	...	...	...	98	1,370½
Oregon-Wash'gton R. R. & Nav. Co.	...	...	...	...	...	...	...	...	1	2	...	...	...	...	3	...	2	...	...	...	...	...	...	...	...	8	232½
Vandalia	...	...	1	...	...	2	...	2	3	3	11	1	2	...	...	...	1	...	...	...	...	...	...	...	...	26	352¼
Western Maryland	...	...	1	...	...	2	2	13	3	12	5	5	2	1	2	2	3	3	...	...	...	...	...	...	...	56	998¼
Western Pacific	...	4	...	1	...	6	13	29	17	4	15	3	5	...	1	1	6	1	...	...	...	1	...	...	...	107	1,426½
Totals	46	56	16	113	26	222	444	915	645	893	960	782	256	378	222	154	325	219	53	15	13	11	8	4	6	*6,790	*134,750½

Average size of motor, 19.84 hp.

(a) Includes 1 motor of 440 hp. (b) Includes 3 motors of 350, 450 and 1,400 hp., respectively. (c) Includes 3 motors of 370 hp. each. (d) Includes 1 motor of 375 hp. (*) Includes the 8 foregoing motors of a total of 4,125 hp.

TABLE I.

RAILROAD	Total Pass. Cars Operated	Total Cars Electric Lighted, Owned by R. R. Co.	Cars Electric Lighted, Operated by R. R. Co.	Number Cells Lead Battery	Number Cells Nickel Iron Battery	Gas Lighted Cars	Oil Lighted Cars	Combination with Electric	HEAD END SYSTEM: Cars with Turbine Sets (10 kw. or Over)	HEAD END SYSTEM: Cars with Battery Used in Head End Trains	AXLE GEN. SYSTEM: Number of Cars, 60 Volts	AXLE GEN. SYSTEM: Number of Cars, 30 Volts	AXLE GEN. SYSTEM: Number of Cars, 24 Volts
1—Atchison, Topeka & Santa Fe System	2,086	624	924	17,685	39	639	523	359	...	...	...	624	...
2—Atlanta, Birmingham & Atlantic	67	...	...	...	825	...	34	31	...	...	...	33	...
3—Atlantic Coast Line	678	67	67	494	1,175	294	332	2	...	...	...	67	...
4—Baltimore & Ohio	1,207	240	247	3,328	1,625	619	348	25	...	.	24	162	...
5—Bangor & Aroostook	90	6	6	16	...	30	44	4	...	...	...	4	...
6—Boston & Maine	1,940	33	33	...	...	1,212	673	9	...	...	...	42	...
7—Buffalo, Rochester & Pittsburg	103	50	54	832	...	45	7	1	...	...	...	50	...
8—Canadian Pacific	2,781	454	454	9,279	1,672	1,923	397	24	1	...	...	4	450
9—Central of Georgia	.	32	32	96	650	...	...	...	...	...	...	32	...
10—Central Railroad of New Jersey	770	148	148	...	3,753	622	...	...	...	...	...	145	...
11—Central Vermont	111	9	9	142	117	29	79	2	...	...	...	9	...
12—Chicago & Alton	108	.	61	912	...	112	28	34	.	...	2	35	...
13—Chicago & Eastern Illinois	190	68	68	1,248	...	45	77	16	..	...	.	68	...
14—Chicago & North Western	1,785	305	305	3,170	25	1,032	651	262	20	43	16	72	...
15—Chicago & Western Indiana	..	...	...	...	...	30	...	...	...	...	...	..	...
16—Chicago, Burlington & Quincy	1,290	755	855	...	...	38	482	593	52	100	...	10	...
17—Chicago Great Western	188	68	94	640	1,350	50	40	...	...	...	...	94	...
18—Chicago, Indianapolis & Louisville	114	26	...	416	...	57	28	3	..	...	...	24	...
19—Chicago, Milwaukee & St. Paul	1,663	950	950	5,700	...	14	651	950	68	208	11	2	...
20—Chicago, Rock Island & Pacific	1,166	421	421	7,136	...	580	65	65	...	...	6	415	...
21—Chicago, St. Paul, Minneapolis & Omaha	340	12	...	352	...	203	131	50	6	...	...	9	...
22—Cincinnati, Hamilton & Dayton	138	19	19	320	..	42	77	17	.	...	1	18	...
23—Cleveland, Cincinnati, Chicago & St. Louis	591	159	159	2,960	25	286	146	5	...	...	27	132	...
24—Colorado & Southern	158	9	9	144	...	68	90	9	...	...	1	8	...
25—Delaware & Hudson	461	9	9	128	125	157	220	4	...	...	4	5	...
26—Delaware, Lackawanna & Western	...	207	207	3,296	175	...	...	5	...	...	...	207	...
27—Denver & Rio Grande	410	69	62	892	100	216	119	8	...	...	2	60	...
28—Duluth, South Shore & Atlantic	69	24	24	...	...	30	30	...	1	...	...	...	...
29—El Paso & Southwestern	74	30	30	528	...	35	4	5	...	..	1	29	...
30—Florida East Coast	116	24	21	16	...	25	62	3	...	...	...	24	...
31—Galveston, Harrisburg & San Antonio	569	64	157	2,232	125	378	127	...	..	...	...	157	...
32—Grand Rapids & Indiana	121	41	45	1,200	...	...	76	...	...	...	1	6	...
33—Grand Trunk Pacific	302	65	67	1,630	219	2	65	...	...	...	...	38	27
34—Great Northern	1,224	686	686	6,044	...	108	271	493	62	...	29	1	...
35—Illinois Central	1,204	359	359	1,040	7,056	511	474	...	...	...	...	354	..
36—Kansas City, Mexico & Orient	...	3	...	48	25	32	...	2	...	...	1	2	...
37—Lake Erie & Western	65	4	4	64	...	33	32	...	...	...	...	4	...
38—Lehigh Valley	640	405	405	6,413	125	42	49	...	...	...	...	400	...
39—Louisville & Nashville	667	164	164	2,208	656	23	491	...	...	...	...	162	..
40—Michigan Central	555	154	154	3,040	...	229	181	1	.	..	6	148	...
41—Minneapolis, St. Paul & Sault Ste. Marie	464	144	..	2,356	...	43	264	...	...	...	...	144	...
42—Nashville, Chattanooga & St. Louis	249	32	32	48	750	87	125	5	...	...	...	32	...
43—New York Central (East of Buffalo)	...	...	..	...	...	...	...	...	...	...	...	...	...
44—New York Central (West of Buffalo)	...	...	...	...	...	...	...	...	...	...	...	...	...
45—New York, New Haven & Hartford	2,261	751	751	11,803	1,500	1,415	96	2	..	...	17	734	...
46—New York, Ontario & Western	225	13	13	..	325	164	49	1	...	...	...	13	...
47—Pennsylvania R. R.	3,719	2,337	...	47,920	30,400	1,240	...	...	...	...	...	296	...
48—Pennsylvania Lines West	1,350	724	724	25,168	54	4	622	...	...	..	53	...	...
49—Philadelphia & Reading		147	147	16	...	1,006	...	15	...	...	...	147	...
50—Pullman Co.		6,234	...	99,744	...	..	...	...	...	...	...	...	...
51—St. Louis & San Francisco	781	218	287	4,608	..	312	182	...	...	...	...	287	...
52—Seaboard Air Line	435	122	1	752	2,900	125	139	4	...	...	7	116	...
53—Southern Ry.	...	258	516	8,290	50	...	..	...	..	...	...	258	...
54—Southern Pacific	1,524	172	377	3,190	1,250	1,201	151	...	23	6	13	116	...
55—Texas & Pacific	237	14	15	176	150	190	33	4	...	...	...	14	...
56—Texas City Terminal	...	2	2	...	...	...	...	...	...	...	...	...	...
57—Union Pacific	846	350	545	2,000	2,200	212	55	258	48	42	41	3	...
58—Oregon Short Line	304	126	126	64	775	172	8	124	6	8	1	19	...
59—Oregon-Washington R. R. & Nav.	296	129	129	498	300	19	36	127	9	20	7	...	...
60—Vandalia R. R.	...	60	..	1,920	..	21	87	...	...	...	10	...	...
61—Wabash-Pittsburgh Terminal	13	...	...	...	...	6	7	...	...	...	...	...	...
62—Western Maryland	150	27	27	592	...	46	77	...	...	...	...	27	...
63—Western Pacific	55	48	48	784	...	1	...	1	...	...	...	49	...
Totals reported	37,803	18,671	11,044	292,568	61,891	27,213	8,970	3,523	296	427	281	5,596	477
15 Roads reported 1912 to 1915	4,808	2,170	921	11,737	2,452	4,522	2,973	771	39	68	39	590	213
Grand total	42,611	20,841	11,965	304,305	64,343	31,735	11,943	4,294	335	495	320	6,186	690

A—Total mileage divided total belts.
B—Individual record each car.
C—No method.
D—Broken balls.
DD—Worn out.
E—Broken races.
F—Mounting.
G—Lack of lubricant.
H—Dirt and sand.
I—Failure of lubricant.
J—Scrap or pig iron.
K—Castings.
L—Rails.
M—Yard materials.
N—Good results and low

Shop Practice

In accordance with the instructions of the executive committee, the work of the committee on shop practice is divided in three groups, as follows: Sub-committee "A" on compressed air and its application. Sub-committee "B" on electric welding. Sub-committee "C" on maintenance and repairs.

In view of the fact that all railroad men have been working under extremely high pressure during the past year, the subcommittees are to be commended on the excellence of their reports, especially when it is realized that to do this work at all meant more than the usual personal sacrifices.

E. Wanamaker,
Chicago, Rock Island & Pacific, Chairman.

Sub-Committee "A" on Compressed Air and Its Application

Your last year's committee on compressed air covered the subject of its generation almost exclusively, but it was suggested that in this year's report they take up the uses and abuses of compressed air in shops, yards, etc., and the comparison of electric and pneumatic tools.

The Uses of Compressed Air in Railroad Shops

Compressed air, which was used before electricity as a transmitter of power, is used in practically every railroad shop in the country, and besides being used it is also much abused at many of these points.

Compressed air has the possible advantage over electricity in that means of utilizing it can be cheaply and easily manufactured. It is largely owing to this fact that it has been developed for railroad shop and yard work. It has the same disadvantage, however, as using a cheap but inefficient motor; the first cost is low, but the consumption of power is high. This might not at first be thought a serious consideration, but a check of several shop power plants showed that, not deducting for the exhaust steam, the shop air compressor consumed over 30 per cent of all the steam generated by the shop power plant. This is due to several causes:

First: The use of compressed air has been developed for various classes of shops, so that each individual shop, roundhouse, and yard that makes up a group of railroad shops has its air lines and air tools.

Second: Unlike an electric transmission system a compressed air system can have a large number of leaks without causing immediate trouble other than an increased load on the air compressor. Even with careful supervision over the pipe lines there are always leaky valves developing, valves carelessly left partially open, or leaky air hose left with the pressure on it, while the compressor runs on twenty-four hours in the day, compressing air to be wasted.

Third: As shop air lines are constantly being extended it is not at all unusual for the feeders to be outgrown. This is a frequent cause of complaint, the complaint usually being that the compressor is too small, whereas, in this case, the compressor is not to blame. In planning a compressed air system, it is most important to get the mains and the reservoirs large enough not only to take care of the present but to provide for future growth.

Fourth: As a usual thing, the smaller shops are dependent on one air compressor alone, which require that this compressor run twenty-four hours in the day and three hundred and sixty-five days in the year. The result is that the engineer postpones any heavy repairs on the air compressor as long as he possibly can with a corresponding increase in the coal bill for which the air compressor is often not suspected.

All in all, the air compressor and the compressed air equipment are very important and useful parts of a shop's equipment, but unless great care is taken they are much less efficient than they should be.

Electric Driven Compressors

Where a steam plant is necessary regardless of whether a steam driven compressor is installed or not, especially when the greater part of the exhaust steam is needed for heating during a portion of the year, and further when a steam driven compressor can be installed in the power plant, and operated without the need of an additional engineer, an electric driven compressor cannot show much, if any, economy over the steam driven machine. The advantage of the electric driven compressor is that it can be located near the point where the air is to be used, consequently long pipe lines can be avoided. With the electric compressor, as well as with the steam driven compressor, a certain amount of power is consumed whenever the machine is running idle. A recent check of a motor driven, two stage compressor of about 500 cu. ft. per minute capacity showed that the electrical energy used, while the equipment was running unloaded, was 17 per cent of the amount used when compressing air to 110 lb. pressure. Of course, this loss may be avoided, especially with the smaller sized compressors, by installing an automatic starter for the motor controlled by a pressure regulator. The advisability of such an installation depends largely on whether there are fairly long periods when the compressor may be shut down if equipped in this manner. If the compressor is required to start every few minutes, it would be more advisable to install an unloading device on the compressor and permit it to run constantly at full speed. With a plant using one or more electric driven compressors, the question of whether the equipment shall be located at one point or distributed at two or more points depends on the first cost of the installation, the cost of transmitting the air and the electricity to the desired points, the diversity of the load and the cost of attendance. As these items vary for each plant considered, it is impossible to lay down a definite rule. In the case of yards located at considerable distances from the steam power plant, it would be cheaper to transmit the electricity to the desired point than to transmit the compressed air with the same percentage of loss. On the other hand with a fairly compact shop plant, the additional cost of a pipe line designed to transmit the air efficiently from one point would be counterbalanced by the advantage of having all of the compressor equipment under one supervision.

Design of a Compressed Air System

The diagram submitted shows an example of compressed air piping at a roundhouse point. It should be noticed that care has been taken to have several air reservoirs distributed throughout the plant to reduce friction loss and to keep the air as dry as possible, each reservoir acting as a settling tank for moisture.

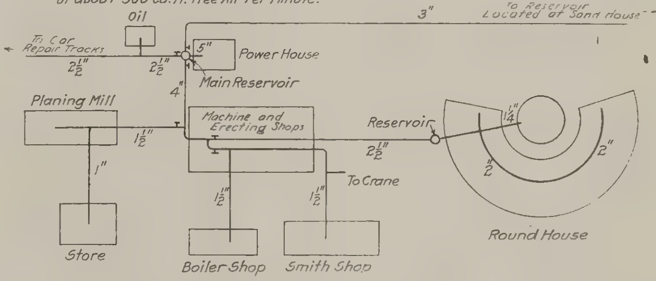

Note: Based on a Compressor with capacity of about 900 cu. ft. Free Air Per Minute.

Fig. 1—Diagram of Compressed Air Piping for Round House Plant

Care has also been taken to have the mains to the different buildings, or groups of buildings, separated as much as possible, and to have valves located in the different lines. By this arrangement, the air can be shut off from all shops not requiring air, as at night or on Sundays, and still leave the line to the roundhouse, etc., open. This has the added advantage of permitting repairs to be made on part of the system without the necessity of shutting down the compressor.

Cost of Leaks in Air Lines

The importance of keeping all unused air lines shut off and of keeping all lines in first-class condition may be emphasized by taking a concrete example.

Assume that air compressed to 100 lb. pressure at a certain shop is costing 4 cents per thousand cu. ft. of free air. A hole 1/16 in. in diameter in the pipe line would permit a leak of 6.45 cu. ft. of air per minute, which would cost 37 cents per day of 24 hours, or $135 per year. The following figures are the results of a test for air leakage, which was run at the shop and terminal plant of a railroad entering Chicago. At the time the test was run, there were no machines in operation, therefore, the total leakage was due to leaks in the air line. This line was originally installed about 25 years ago, but has been continually repaired and added to since then. The figure for steam consumption per cu. ft. of air was obtained in a previous test.

After the system was filled to a gage pressure of 100 lbs. per square inch, the compressor was stopped. When the gage pressure had reached 40 lb., the time was noted. The amount of free air pumped into the system was 21,331.4 cu. ft. As the system started to leak as soon as pressure was put into it, the time of leakage is calculated from the time the engine was started. The pressure during this time was variable, going from 0 lb. gage to 100 lb. and back to 40 lb., but as the flow of gas through an orifice is practically constant when the inside pressure is more than two times that of the receiving gas, it is safe to assume that the rate of leakage was constant.

A leakage of 15 per cent was assumed during the time the compressor was working. Substracting this amount from 21,331.4 cu. ft. there was .85 x 21,331.4 or 18,131.69 cu. ft. of free air in the system when the compressor was stopped. As there was no way to determine whether or not the 15 per cent leakage assumed was correct, it was necessary to assume a per cent loss and after calculating check back and find how the assumed and calculated values checked.

DATA

Total air in system at 100-lb. gage..........18,131.69 cu. ft. free air.

Now $\frac{(V1 — V2)}{(V1)} = \frac{P1 — P2}{P1}$

V1 = original volume of free air at....100-lb. gage = 18,131.69
V2 = volume free air at................40-lb. gage = ?
P1 = absolute pressure at ....100-lb. gage = 115 lb.
P2 = absolute pressure at..............40-lb. gage = 55 lb.
Let V = (V1 — V2) = volume free air leaked.

Now $V = V1 \frac{(P1 — P2)}{P1} = 18.131.69 \frac{(115 — 55)}{115}$ = 9,446 cu. ft. of free air in 55 minutes, or 171.7 cu. ft. per minute.

Steam used per cu. ft. of free air = .1306 lb.
Steam used in pumping leaking air, per minute,
.1306 × 171.7 = 22.4 lb. = 1,344 lb. per hour.

$\frac{1.344}{30}$ = 44.8 boiler hp. hrs, at $.005 per boiler hp. hour.

Cost per hour of leaks = $0.224
Cost per day (24 hr.) = 5.38
Cost per month ...... = 161.40
Cost per years ...... = 1,936.80
Add 50% for machine leaks when shop is in full operation = $2,905.20.
Cost of producing 1,000 cu. ft. of air equals

$\frac{.1306 \times 1000}{30} \times .005 = \$.02175$

Note that the air compressor was not as efficient as it should be.

Electric vs. Pneumatic Portable Tools

Portable tools can be divided into two classes: rotating tools such as drills, motors, etc., and reciprocating tools such as riveting hammers, etc. For the reciprocating class the electric tool, in its present stage of development seems to have no advantages over the air tools. It can merely be said that for light work there are electric tools of this type on the market. For rotating tools the following table shows some of the advantages and disadvantages of the two types:

Lightness. The penumatic tool is considerably lighter and consequently easier to handle than the electric tool. The increased weight of the electric drill over the pneumatic varies roughly from 10 per cent in the larger sizes to 25 per cent in the smaller. However, the electric tool has the advantage that a portable electric cord is much easier to handle than an air hose. It has also sometimes developed that two men with an electric drill will accomplish more than twice as much work as one man with a pneumatic drill.

Efficiency. This is the chief advantage that the electric tool has over the pneumatic. This is due first to the tool itself, and, especially as the work varies from second to second, a portable pneumatic tool speeds up the instant the load is removed, thus taking more and more power as the load is released, whereas with the electric tool the exact reverse is true. On full load the efficiency of the electric drill varies from 30 per cent in the smaller sizes to as much as 80 per cent in the larger sizes, whereas the efficiency of the pneumatic tool varies from about 18 per cent to 35 per cent, depending on the size. The total system of generation and transmission is usually more efficient in the case of electricity than in the case of air. The instant current is turned off of the electric tool the supply of energy ceases, there are no valves, air hose, couplings and pipes to leak.

First Cost. The first cost of a pneumatic tool is less than that of an electric tool.

Trouble from Freezing. Electric tools are free from the annoyance that the air tools often give of freezing up in the winter time.

Cost of Maintenance. Accurate figures have not been obtained by the committee as to relative cost of maintenance of the two types of tools. Electric tools will not stand the abuse that pneumatic tools will, but where not abused it is probable that the maintenance of electric tools is considerably less than that of pneumatic.

Sub-Committee: J. E. GARDNER, Chicago, Burlington & Quincy, chairman; H. R. BUCKS, Oregon Short Line; T. F. FOLTZ, Washington Terminal Company; L. M. GAZIN, Atchison, Topeka & Santa Fe; H. C. MELOY, New York Central; R. M. PACHALY, Chicago, Rock Island & Pacific.

Sub-Committee "B" on Electric Welding

In submitting the following report your committee has made an attempt to outline the elementary principles of electric arc welding practice. The application of the process in railroad shops is comparatively new, and it is possible that within a very short time the practices here recommended will become obsolete due to the rapid progress which is being made in the art of welding. The lack of authoritative literature on the subject, together with the great rapidity of the introduction of the process, has left each shop to proceed on its own resources and to solve the problems of welding through the ingenuity of the shop organization. The purpose of this report is to summarize, so far as possible, the information available on the installation and use of electric arc welding equipment in railroad shops.

Electric arc welding is a particular kind of autogenous welding. Autogenous welding is the kind of welding which is accomplished with heat but without the use of pressure. Forge welding, butt and spot welding are welding processes in which both heat and mechanical pressure are used to produce cohesion of the molecules of the pieces being welded at the point at which they are to be joined. The difference between these two kinds of welding is entirely due to the difference in the intensity of the heat used. At the present time there are three methods in use of producing a heat of such intensity that metals can be welded without the use of mechanical pressure—the thermite reaction, the oxy-acteylene flame, the electric arc.

The Electric Arc

An electric arc is formed when a current of electricity passes from one conductor to another conductor through an incandescent vapor. The conductor *from* which the current passes into the incandescent vapor is called the positive electrode or anode, the conductor to which the current passes from the incandescent vapor is called the negative electrode or cathode. It is estimated that approximately 75 per cent of the resistance offered to the passage of the current of electricity from anode to cathode occurs at the anode. The remaining 25 per cent of the resistance is in the vapor and in the cathode. It is generally believed that more resistance is offered by the cathode than in the vapor of the arc in short arcs such as are used in the arc welding process. Since the amount of heat in any part of the arc or electrodes is proportioned to the amount of resistance offered by that part of the arc to the passage of the electric current, it is evident that the visible arc or flame liberates a comparatively small percentage of the total heat of the arc. The largest part of the heat is liberated at the positive electrode.

Polarity for Welding

Owing to the fact that the heat of the arc is produced in greater quantity at the positive electrode, in electric arc welding practice it is necessary to consider the matter of popularity.

In metal electrode welding, the mass of the welding wire which is being melted is usually less than the mass of the piece to which the metal is being added so that the amount of heat lost by conduction is greatest on the piece to which the metal is being added. For this reason, the piece of greater mass is made the positive electrode. In certain cases, such as the welding of very thin sheet metal, the wire being melted is made the positive electrode in order to reduce the tendency of the arc to burn through the sheet metal.

When the slag coated electrode is used, the wire is usually made the positive electrode. In this case, the arc operates under a slag so that a considerable percentage of the heat otherwise radiated is retained in the vicinity of the arc. This conservation of the heat on the heavier piece permits the higher rate of melting of the metal being added.

It is necessary to use the carbon electrode as the cathode in carbon electrode welding. The current of electricity must pass from the metal to the carbon, otherwise the carbon will be carried into the metal being welded causing hardness.

Amount of Heat Used in Electric Arc Welding

The electric arc transforms electrical energy into heat. The heat is intense because a comparatively large amount of energy is transformed into heat in a small area. One kilowatt hour of electrical energy is equivalent to 3,413 B.t.u. of heat. Thus an arc in which the current is 150 amperes and the voltage between electrodes is 20 volts will transform three kilowatts of electrical energy into 10,239 B.t.u. in one hour of continuous operation. Similarly, one cubic foot of acetylene gas burned in oxygen will produce 1,555 B.t.u. of heat. Thus the three kilowatt hours of electrical energy will produce the same amount of heat as may be produced by approximately 6.6 cu. ft. of acetylene burned in 7.5 cu. ft. of oxygen.

The amount of heat which can be used in the arc welding process depends largely on the size of the wire electrode being used. The kind of wire being used and the character of the piece being welded also affect this factor. The following table to itsshows the limits indicated by present practice:

Kind of Electrode	Size	Current	Voltage	Work
Mild Steel....	⅛ in.	60-90	14-16	2 in. flues
Mild Steel....	5/32 in.	110-140	16-20	5 in. flues filling
Mild Steel....	3/16 in.	150-180	18-25	filling
Carbon........	¾ in.	250-350	35-50	cutting welding
Carbon........	1 in.	350-500	35-50	cutting welding

Elementary Metallurgy

The electric arc welding process (metal electrode) is, reduced to its simplest terms, simply a means of melting steel wire and allowing it to flow while molten on to another piece of steel which has been melted over a local area. There are three important changes which occur in the metal during the process:

1. The effect of mechanical treatment is entirely eliminated over the area heated to a plastic or molten state. The metal thus affected becomes cast steel.

2. Unless the molten metal is protected by a slag covering, it is oxidized to a certain extent by the oxygen present in the atmosphere. This oxidation tends to make the metal cold short.

3. A large percentage of the impurities (carbon, manganese, nickle, vanadium, chromium, etc.), which may be present in the steel effected by the welding process before the operation, is vaporized or oxidized and has disappeared after the operation.

The net result is that in bare wire welding, the metal obtained in the weld may be as high in tensile strength as the metal in the original piece being welded. It will be rather low in ductility, but will be soft if the metal before the operation was not over .35 per cent in carbon content.

No method has been demonstrated up to the present time of giving the cast steel in the weld the same characteristics to the same degree as those found in flange steel. The same tensile strength can be obtained and equal softness; but with the present development of the art of welding with the electric arc, equal ductility has not been produced. The cast steel in the weld may have practically the same characteristics as the cast steel used in locomotive construction so far as tensile strength, ductility and softness are concerned.

In spite of the comparatively low degree of ductility of the metal obtained in the weld, the process is entirely practical as a means of welding both cast steel and boiler plate owing to the fact that the welded area may be reinforced where great resistance to fracture must be produced. The net result of this practice is to stiffen the welded section to such an extent that under severe stress the original and unwelded section will fail before the metal in the weld is strained to the point of rupture.

Application in Railroad Shops

The simplest application of electric arc welding in the railroad shop is the "building up" operation. Practically every steel casting on the locomotive is subject to wear at several points. Wearing surfaces are rapidly worn down and bolt holes wear large.

The metal electrode process should be used for these building up operations for the following reasons:

1. Locomotive steel castings welded with the carbon arc should be annealed before being put in service. The locomotive shop is not equipped to anneal castings.

2. Metal may be more accurately placed with the metal electrode process than with the carbon electrode process. Time saved in the welding operation using the carbon arc is more than lost in the machining operations.

3. Less skill is required to operate the metal arc than the carbon arc for building up operations.

4. There is no possibility of hard spots when the metal electrode process is used for the operation.

Most of the building up operations should be done with 3/16 in. electrode. The use of smaller electrodes is not economical owing to the slow speed. The use of the larger bare wire electrode is not good practice owing to lack of control of the metal.

Welding Boiler Plate

Welding in the firebox should be done with ⅛ in. or 5/32 in. electrode. The best metal is obtained in the weld with these sizes. The amount of heat is as small as can be economically used. It is evident that owing to expansion and contraction difficulties, the quantity of heat it is possible to use in welding flues or firebox sheets is limited.

The ideal preparation of a set of flues for welding is as follows:

1. Put flues in exactly as if they were not to be welded.

2. Fire the boiler, or, better still, send the engine out for a run. The object is to burn the oil out from under the beads of the flues.

3. The flue sheet should then be brushed with a stiff wire brush or sand blasted. The object is to eliminate, so far as possible, the scale of oxide on the flue sheet and flues. Iron oxide is not a good conductor of electricity and causes difficulties with the arc which in turn may produce a poor weld.

The welding of 2 in. flues is done best with ⅛ in. electrode. On sand blasted flue sheets 90 to 100 amperes is enough current. Flue sheets that have a thick coat of oxide require from 120 to 130 amperes on this size wire. Five in. flues should be welded with 5/32 in. electrode with 120 to 140 amperes depending upon the condition of the flue sheet.

Cracks and patch seams offer the most difficult problems to the operator. A crack should be located and at least two inches beyond each end a ½ in. hole drilled. The edges of the crack should then be beveled so that the operator can get at them to make the weld. On horizontal cracks, the lower edge does not need to be beveled but should be chipped to give a square edge. The upper edge should be beveled at least 45 deg. Vertical cracks should be beveled from 30 deg. to 45 deg. on each side. The less material removed from the crack the better. All welds should be made with the least possible amount of metal between the edges of the original material.

If the crack or seam is a long one, the metal should be put in alternate sections 4 in. to 6 in. long. The operator should put one layer of metal in each of these alternate sections starting near the center of the seam or crack. The open sections can then be filled starting at the coolest point. Successive layers of metal can then be applied until the seam is completed. Wherever possible, at least 30 per cent of reinforcing should be applied so that the cross-section through the weld is 30 per cent greater than the section of the original plate. After each layer of metal is welded into the seam, it should be thoroughly brushed with a stiff wire brush to remove as much of the oxide as possible. Where the sand blast is available and can be used on the job the results will justify the expenditure of time necessary to clean the metal between layers. The same general care should be taken in the welding of locomotive frames as in the case of the boiler plate of the firebox.

Aside from the use of judgment in the application of the electric arc welding process, there are three rules which the operator must observe to get the best results in welding: 1. Hold a short arc. 2. Use a low current. 3. Always work on clean metal.

Cost Data

The following cost data were obtained in one of the largest locomotive shops of the country. Period covered seven months, cost of electric power 2 cents per k. w. h.

TABLE I

STATEMENT OF WORK PERFORMED WITH ELECTRIC WELDER AT LOCOMOTIVE SHOPS.

1916	No. of engines	No. of flues welded	Actual time welding, hr. and min.	Labor	Material	Current	Total cost, actual welding	Time preparing for welding, hr. and min.	Cost preparing for welding	Total cost to engines	Average cost per engine
Total for 2-in. flues	247	42,640	2,811′ 15″	$990.77	$181.09	$843.72	$2,015.58	222′ 45″	$80.39	$2,093.97	$8.48
Total for 5-in. flues	196	5,034	1,473′ 45″	520.01	85.47	442.16	1,047.64	24′ 00″	10.08	1,056.12	5.39
Total for smoke consumer tubes	244	1,946	122′ 00″	42.85	9.76	36.60	89.21	....	......	89.21	.37

MISCELLANEOUS JOBS

1916	No. of operations	Labor	Material	Current	Total cost	Other method	Saving	Saving per operation
January	461	$183.07	$47.88	$155.70	$386.65	$1,176.58	$789.93	$1.71
February	433	218.08	59.89	187.70	465.67	1,558.56	1,092.89	2.52
March	584	253.37	64.57	199.13	517.07	1,871.44	1,354.37	2.32
April	325	172.92	42.62	134.20	349.74	1,232.65	882.91	2.72
May	487	228.22	60.62	175.52	464.36	1,839.54	1,375.18	2.82
June	579	210.09	54.94	175.52	440.55	1,726.10	1,285.55	2.22
July	523	165.97	41.12	135.62	342.71	1,501.33	1,158.62	2.22
Totals	3,392	$1,431.72	$371.64	$1,163.39	$2,966.75	$10,906.20	$7,939.45	$2.34

TABLE II

MISCELLANEOUS ELECTRIC WELDING—LOCOMOTIVE SHOP—ONE MONTH

Description	No. of operations	Labor	Material	Current	Total cost	Other method	Saving
Bumper Beam	1	$1.41	$0.33	$1.35	$3.09	$5.00	$1.91
Brake Shoe Heads	102	11.79	2.48	9.55	23.82	80.58	56.76
Brake Hanger Bracket	1	.33	.02	.08	.43	1.25	.82
Crossheads—Piston	17	12.96	3.29	10.53	26.78	133.06	106.28
Crossheads—Valve	22	2.39	.55	1.95	4.89	13.93	9.09
Crosshead Pins	3	.83	.18	.53	1.54	4.47	2.93
Deck Castings	7	30.23	6.90	20.70	57.83	484.32	426.49
Driving Boxes	4	2.10	4.20	1.80	8.10	105.48	97.38
Driving Box Lugs	10	1.08	.33	.88	2.29	6.90	4.61
Frames	2	5.11	1.25	4.20	10.56	57.84	47.28
Frame Cross Brace	1	2.59	.60	1.80	4.99	21.75	16.76
Eccentric Blades	5	.96	.21	.86	2.03	5.44	3.41
Eccentric Crank	1	.19	.05	.15	.39	12.74	12.35
Guide Bars	69	99.52	28.91	86.33	214.76	423.03	208.27
Guide Yoke	1	.66	.10	.30	1.06	9.74	8.68
Levers—Combination	17	2.66	.60	1.73	4.99	32.37	27.38
Links	33	3.44	.89	2.35	6.68	36.41	29.73
Link Hangers	12	1.36	.30	.90	2.56	3.24	.68
Link Saddles	2	.59	.10	.45	1.14	8.32	7.18
Miscellaneous	6	1.48	.19	.50	2.17	4.86	2.69
Quadrants—Teeth	3	.28	.05	.23	.56	2.43	1.87
Rods—Main	9	2.48	.75	2.18	5.41	9.99	4.58
Rods—Side—Grease Plug Holes	106	20.61	2.70	10.03	33.34	89.04	55.70
Rods—Side—Spade Pin Holes	1	.65	.23	.68	1.56	12.29	10.73
Rod Straps	7	4.16	1.10	3.30	8.56	53.78	45.22
Reverse Lever Heels	3	.57	.15	.45	1.17	7.80	6.63
Reverse Lever Latches	6	.66	.13	.53	1.32	11.55	10.23
Spring Saddles	8	2.19	.60	1.80	4.59	22.99	18.40
Spokes—Driving Wheel	9	6.01	1.50	4.20	11.71	42.50	30.79
Shop Tools and Machinery	2	.72	.13	.50	1.35	6.00	4.65
Tail Sheet	1	.33	.05	.15	.53	1.50	.97
Tumbling Shaft	2	3.13	.85	1.00	4.98	49.21	44.23
Tender Truck Equalizers	8	4.18	.80	3.15	8.13	78.30	70.17
Transmission Hangers	6	.57	.10	.38	1.05	1.38	.33
Total	487	$228.22	$60.62	$175.52	$464.36	$1,839.54	$1,375.18
Net saving for month $1,375.18							

Electric Arc Welding Equipment

The power required for electric arc welding at the electrodes is low voltage direct current. The metal arc requires from 75 to 180 amperes at 15 to 30 volts. The carbon arc requires from 250 to 400 amperes at 40 to 50 volts. The only object in using welding equipment is to get power of this nature economically. So far as welding is concerned, quite as good work can be done with resistance ballast across 250 volts direct current, as is possible with the most refined and highly developed equipment.

There are two types of equipment on the market which may be described as constant voltage type and variable voltage type.

The constant voltage type is a motor generator set which takes power from the shop mains and delivers on the generator end a practically constant low voltage. A resistance ballast is used between the generator and the welding arc to limit the current at short circuit. The power used in the resistance ballast is of course wasted. The low voltage direct current power is carried over the shop on heavy cable to the welding outlets.

The variable voltage type is a motor generator set which takes power from the shop mains and delivers on the generator end the voltage required for welding without the use of resistance ballast. The inherent characteristic of the generator is such that the short circuit current is limited without the use of resistance ballast. Inductive ballast is used to stabilize the arc. This type of equipment is made only in single operator units. With this type of equipment the low voltage distribution system may be eliminated. The motor is fed directly from the shop lines.

Single operator units of either type may be made portable. Large constant voltage multiple operator units must be located at definite points, although the resistance banks may be made portable if the low voltage distribution system is made heavy enough to eliminate interference between operators due to line drop.

The desirability of any installation of welding equipment is based on the following points: 1. Reliability—flexibility. 2. Operation cost. 3. Cost of the installation complete, including wiring, apparatus and installing.

At the present time it appears that 150 amperes capacity for each 5 tracks in a locomotive shop or for each 15 tracks in an engine house is sufficient capacity.

Protective Shields

An operator's shield for building up operations which is very satisfactory can be made of a soft pine board with a small slot in it for the protective glass. Firebox work requires a head shield which should be made of hard fibre. The color combination in the protective glass is of importance. Two red glasses and one blue glass or two reds and a green give good results. Special glass put out under various trade names is also satisfactory. As a rule the operator tries several combinations until he gets one which seems to suit his eyes best.

While the operator is working outside the fire box, the other men should be protected from the light of the arc by screens. Portable screens should be used where work is done on the floor. Where a regular welding bench is provided, permanent curtains should be provided. The screens should always be designed to protect the crane operators from the flash of the arc.

Shop Organization

The importance of the welding operations in a locomotive shop or engine house is so great that it is necessary for the work to be done under the direction of a competent and responsible member of the railroad organization. On a large system where welding is done at several shops and engine houses it has been found that unless some special effort is made in that direction the practice of one shop has not usually conformed with the practice of the other shops of the system. This leads to a situation in which it is impossible to place the responsibility for the success or failure of the process. A very successful solution to this problem has been made on several systems by the appointment of a supervisor of electric welding who is responsible directly to the general superintendent of motive power. The supervisor of electric welding makes the practice of the several shops uniform so that the failure of one shop to get results from a process can be traced to its origin. The supervisor of electric welding must find a successful way of doing each job and require every shop to perform the operation according to his instructions.

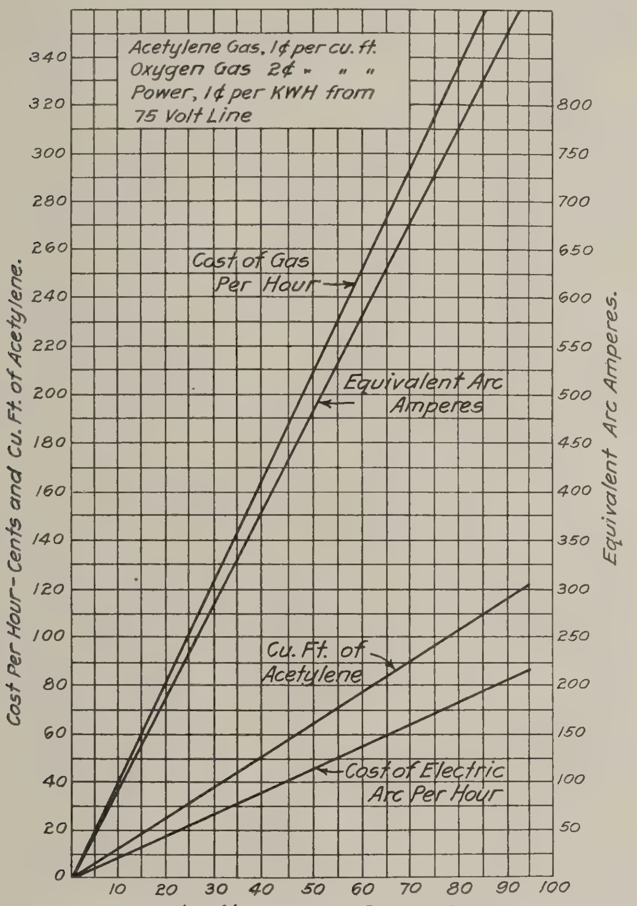


Fig. 2—Curves Showing Comparison Between Cost of Gas and Electric Welding Based on Heat Units per Hour.

When failures of certain operations are reported the supervisor of electric welding can readily locate the trouble since it can only be due to the failure of some particular shop to follow his instructions. In this plan the operators in each shop are responsible to the local shop authorities in the usual way and are responsible only to the supervisor of electric welding for the manner in which they perform the welding operations. The operators in a given shop are usually in charge of a foreman operator, who assigns them to individual jobs and is responsible for their following instructions of the welding supervisor.

Operators are obtained in most cases from a shop organization. On roads where an apprenticeship training is provided most of the operators are men who have just completed the apprentice work. It is desirable to have operators who have had general experience in a railroad shop. In shops which have a local electrician the care of the electric arc welding equipment is handled by the chief electrician. In engine houses the operator of the equipment is usually trained to give the equipment whatever care is necessary.

Standardization of Operations

The tendency at the present time is to standardize the welding operations in the same manner that the machine shop and other operations have been standardized. Where welding operations are thoroughly standardized the work can be paid for on a piece work basis. The standardization of welding operations is comparatively simple on systems which employ a supervisor of electric welding. On other roads it is more difficult to standardize the operations, but the necessity for having them standardized is greater. Ninety-five per cent of the electric arc welding done in railroad shops is on operations which can be standardized. The following factors should be determined for each job of this nature: 1—Size of electrode, 2—Kind of electrode, 3—Current in the arc, and 4—Time required for the operation.

Summary

The application of the electric arc welding process to the repair work in locomotive shops and engine houses is a profitable proposition for the railroad. It is important to the railroads that the shop practice and shop organization be reduced to the most economical basis at the earliest possible moment. While the saving effected by the application of the process was so great that up to the present time the application of scientific management to the electric arc welding practice has not been made to any great extent, it is evident to everyone who is interested in railroad shop management that the time is coming when it will be necessary to cut down cost of this work to the lowest possible figure. This can only be accomplished by intelligent co-operation of the railroads along the lines of furnishing information on the results of their practice.

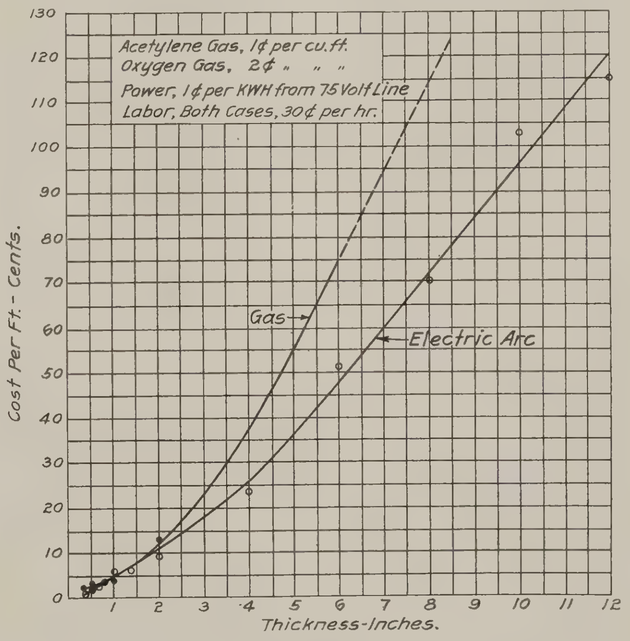


Fig. 3—Curves Showing Relative Cost of Cutting Steel with Gas and the Electric Arc.

Sub-Committee: H. C. Meloy, New York Central, chairman; S. T. Sikes, Southern Pacific; D. C. Wilson, Union Pacific; Robert Kinkead, Lincoln Electric Company; C. H. Quinn, Norfolk & Western; J. H. Bryan, *Railway Electrical Engineer.*

Sub-Committee "C" on Maintenance and Repairs

Maintenance, as it is generally understood, covers upkeep, replacement of broken and worn parts or renewals, while under the item of costs the labor and material must both be included. It will be the object of your committee to briefly mention the different parts of equipment that we have thought advisable that are in use by all roads, so we have therefore taken them up separately as follows:

Turntable Motors

In 1914, at the regular meeting, the question of size of motor to use on a turntable came up and was discussed quite freely and it seemed at that time that there was quite a variation of sizes being used, such as 10, 15, and 20 h.p. and in some cases 2 motors of the same size.

Immediately after this meeting your chairman had an occasion to make load and current tests on an 85 ft. table, and while making these tests it seemed avisable to get some direct data on motor sizes. Each of the results given are averages, which were taken from results that were practically constant and in each case the maximum load was put on the table that it would be expected to handle; that is a 142-ton engine.

Test No.	Watt hrs. per revolution of table	Time in seconds	H.P. required
1	235	71½	14½
2	236.37	69	16.006
3	285.44	68	20.2

A standard portable Westinghouse watthour meter and a stop watch were used for making these tests.

Test No. 1 was taken with as near ideal shop conditions as could be secured, that is, the engine was well balanced, clean circle rail and the motor handled intelligently.

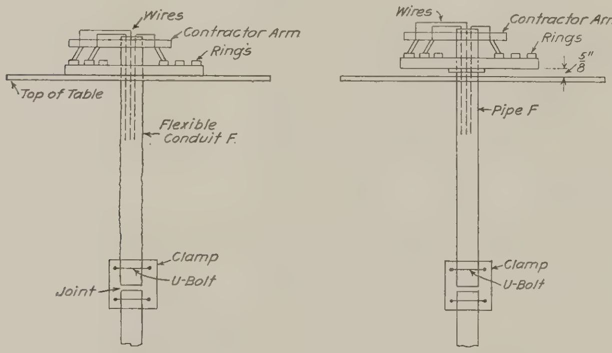


Fig. 4—Underground Contacts for Electric Operated Turntable

Test No. 2 was taken with the same kind of rail, but with an unbalanced engine, as is often done.

Test No. 3 was taken with a very sandy rail and an unbalanced engine. After a table of the same length and with the same load is in motion, we have found the average horse-power required to keep it in motion to be only six.

In conclusion, from the results of tests taken under all conditions, we have found that a 15 hp.p motor will at all times turn the tractor wheel on the track even if the table is not in motion.

As for the correct type of motor to use on a turntable, it is the opinion of this committee that a motor should be used which will have the greatest starting torque and in turn produce the greatest tractive effort. If direct current is the kind of current available, then a series wound motor would be recommended, and if alternating current is available the slip-ring type is recommended. The high resistance end-ring motor would be recommended as the next choice. The high resistance end-ring motor has been tried on turntables by different roads, but considerable trouble has been experienced from burning the insulation off the rotor bars, and from burning the end-rings open, which has considerably increased the maintenance cost. We might mention here that an argument is due from this last statement. It might be argued that the bars do not need any insulation for running to which we fully agree, but they do need the insulation to give a starting torque of sufficient strength required to move a table from rest.

Considerable experimenting has been carried on with this high resistance end-ring motor rotor as to the insulation and rings in order to reduce the maintenance troubles and the final conclusion of these experiments will be given as follows: The end-rings were replaced with an iron ring about ⅜ in. thick, which gives metal enough to rivet and electro-weld the bars to it, and each bar was insulated with mica then covered with an insulating paint before putting them into the slots, the paint being used only to keep the mica from chipping off, this motor repaired in this manner will give service; however, it is admitted it makes an inefficient motor, but as it is not in steady operation, this point is minor.

Turntable Contactors

Nearly all roads have had more or less trouble with the center contactors where an underground service is in use and this method of collecting and supporting the collector has not been much more than experimental, however, it has come under the head of repairs for a long time. The two types of construction herein shown have been in use three years without a single case of trouble, therefore, no repair costs have been charged against them.

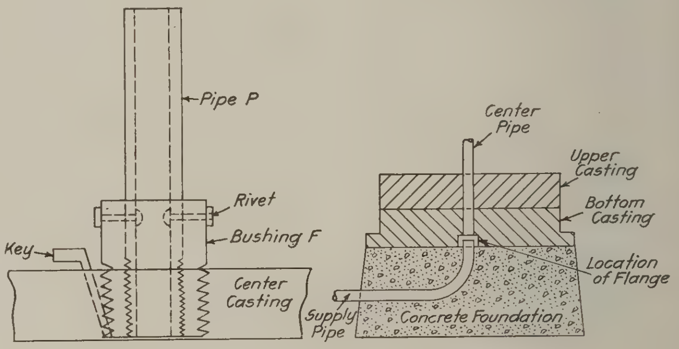


Fig. 5—Foundation Plan for Turntable

Details of the bottom parts of the collectors shown in Fig. 4 are shown in Fig. 5. The pipe P in Fig. 5, which supports the contactor plate, is a heavy iron pipe screwed and riveted to the threaded-bushing F. This bushing is screwed into the table supporting casting and then drilled from the bottom side before installation of the casting, so that after the supporting casting is placed the key can be placed from the top side, thus locking the bushing to the casting.

Referring again to the left-hand part of Fig. 4, it will be noted that, beginning at the joint, the portion marked F is a piece of 1½ in. flexible steel conduit. You will note that there is no weight carried on it and it only has to turn the light collecting arm, therefore, its work is minute.

In the right hand part of the same figure, this same section is a heavy steel pipe and it carries the weight of the collecting rings and support, which are raised ⅝ in. above the table top proper, also the collecting arm is fastened to the top of the pipe. The joint part in the pipe in this case is reinforced with a clamp in addition to the coupling.

In conclusion relative to the maintenance of turntables, it is safe to state that the majority of troubles with the electric equipment are traceable to some other defect of the table, such as long rails on the table or the leading in tracks which cause binding between the table and pit sides, or by engines getting off, or by unbalancing effects, all of which usually stop the motor in some manner or other.

Repairs of Air Compressor Electrical Equipment

It has become common practice during the past three years for the several roads to install air compressor units out in freight yards for the purpose of testing train lines and for inspection of the air equipment on freight cars. As a rule these compressors are located at some point too far away from any steam source so have been designed to operate with electric power, being automatic in their operation, being actuated by the pressure of the air.

Electrical equipment placed away from the regular shops is not under observation of workmen at all times and in fact only when special inspection trips are made to it, therefore, is, so to speak, automatic in its operation.

The automatic air controlled switches, friction clutches, motor bearings, etc., should be inspected at least once a week and any defects made good as new, as it is usually troubles caused by one open phase or circuit that stops the operation of such machines and causes delays, etc. Such installations as these, where no operator is near for long intervals of time, overload switches with time limit, and low voltage relays are recommended as a means of protection rather than depending on fuses, also for protecting the apparatus against blown fuses or one open primary circuit.

It has been your chairman's experience to find more motor troubles on compressors caused by defective valves on the compressor than any other one thing, that is the valves were neglected to such an extent that they would not seat and cause back pressures so that the motor would either slip in the friction clutch and ruin that or open the switches, shutting down the unit entirely.

Gas Electric Cars

The maintenance of the electrical equipment on gas electric-driven cars seems an important subject at this time and worthy of consideration. Failures of the electrical equipment of these cars are in most cases not due to the design or defective apparatus, but more often caused by insufficient maintenance.

The inspection and cleaning intervals of the electrical parts, such as the inside of the motors and controller, should not exceed three days and at least once per month all brushes, holders, insulation, governors, ignition systems, contacts, wiring and lighting apparatus should receive a thorough inspection and cleaning and if defective in any way such repairs necessary should be made to the different parts to make them as good as new.

The governor, which is in connection with the ignition system, should receive special attention and be tested often, because if allowed to become dirty it will be unreliable, which will allow the engine to be over-speeded, thereby causing unusual high voltage, which in turn has a tendency to cause a flash over at the motors. It has been shown by experience and tests that by keeping the outer edge of the motor commutators rounded off, the flashovers are less severe and less liable to occur. It is our understanding that one of the roads has installed a voltmeter in front of the engineer's seat which he uses as a guide for telling when his engine is up to speed or over speeded. At that same time it indicates to the engineer when something is wrong with his engine. Your committee would be pleased to hear if any other roads are using this or any other method other than the regular equipment supplied with the cars.

Lubrication of Electrical Apparatus

Probably one of the greatest sources of trouble with the electric motor and one of the greatest items of maintenance expense comes from the bearings and this, no doubt, will eventually be the cause of the manufacturers adopting ball bearings for all shop motors. However, a considerable part of the present bearing troubles could be eliminated by proper lubrication and cleaning of the bearings. It is not necessary to state how or how often a motor bearing should be cleaned, but we all know that there are only a very few shop maintainers that ever clean out the oil wells. In most cases new oil is added to the old, but the sediment is left in the well, which is wrong.

The several factors that should receive consideration when selecting a lubricant for a motor or generator bearing are: 1—Velocity of the shaft, 2—Weight of the rotating element, 3—Composition of the bearing and 4—Viscosity of the lubricant.

Thus, if the velocity is low and the weight is great, the percentage viscosity of the lubricant should be high and in cases of extreme weights even graphite mixtures have been tested and found satisfactory.

Some of the extreme methods on record of lubricating motor bearings are: 1—Motor bearing oil well filled with soft grease, motor designed with oil rings. No damage had been done because enough was put on top of the bearing so when it heated some of the grease got on the shaft; 2—Oil well packed with waste and car wheel oil. This motor also designed for oil rings; 3—Transil oil used instead of dynamo oil; 4—Any number of cases where black car oil is used. These few cases are cited to show the ruggedness of the equipment.

This committee recommends the use of a good standard dynamo oil for small motors of light rotating weights, and a mixture of two-thirds light oil and one-third heavy oil, such as light valve oil where rotor weights are great—200 or more pounds.

As to the quality of metal for babbitted bearings, common shop babbitt is not good enough for motor and generator bearings and only high grades of alloys of tin and copper or bronze should be used.

Meters

On investigation it is found that a large number of the railroads own watt-hour meters and other instruments. In some cases municipalities have forced all within their corporate limits to buy meters, the railroads included. The deferred or neglected maintenance of all watt-hour meters whether owned by others than the railroad companies or the railroads has proved and is proving expensive. It is recommended that all meters, from which the railroad companies are billed, be tested at least once a year. This can be done in all cases without the knowledge of the owners, if necessary, by connecting the series coil of the portable test set ahead of the service meter in place of a switch blade or a fuse receptacle, and then if any percentage of error greater than allowed by the state commissions is found, a joint test can be asked for with the owners and a rebate decided upon. While it is generally understood that a large percentage of meters run slow with age and wear, reports show that the percentage running fast and the money paid for this percentage will pay for testing all meters with a margin.

Meters owned by the railroad companies should also be inspected, repaired, and tested once a year to see that all jewels, bearings and other parts are in good condition, and that the coils are well insulated and have not been shortened by lightning.

Lightning Arresters

Considerable trouble, delay and expense can be eliminated around shops and power-houses if the lightning arresters receive more attention. Arresters should at least be inspected in the early spring and after each lightning storm if there is any indication that they have discharged during the storm or if any apparatus has been destroyed. The spark gaps should be gaged and set the correct distance apart for the voltage on which they are operating. Each gap should be cleaned and if metal gaps are used they should be polished as often as once every two weeks if placed anywhere where corrosion is rapid. For arresters, where there is a constant static discharge between the metallic gaps the variation of distance and corrosion is even greater, and if allowed to stop discharging for any great length of time by deferred maintenance and repair, insulation breakdowns on some parts of the system may be looked for. Such breakdowns are more expensive than making repairs when necessary or at regular intervals.

The ground wire from the lightning arrester is next in importance to the arrester itself because if its connections are poor the arrester is useless. All connections, if more than one arrester is connected to the same ground wire, should be thoroughly soldered and it has been found good practice to make insulation tests across the spark gap in order to keep ready information as to the ground connection itself. A piece of copper sheeting soldered and mechanically connected to the ground wire and buried six to seven feet makes an excellent ground connection for most soils, but if real sandy soil or soil that dries deep is encountered it is advisable to cover the ground plate with charcoal and to use considerable common salt when filling up the ground hole.

Electrical Operation of Railroad Shops

Centralization of power and the operation of tools either individually or collectively by means of motors has been adopted in the various departments of practically all recently equipped railroad repair shops. The heads of the mechanical departments, appreciating the reduced operating cost and the increased output obtained through these methods, have in many instances modernized their older shops, thus eliminating the use of long lines of shafting and belt drive so far as possible. For a comparatively long time it has been the practice, in modern shops, to drive the larger machines by independent motors and group the smaller machines in such a manner as not to interfere with the operation of cranes, but the disadvantages of this arrangement, as compared with the use of independent motors exclusively, are becoming more and more appreciated, so that each year the ideal railroad shop, with all shafting and belting eliminated, becomes more nearly an accomplished fact.

Group vs. Independent Drive

In making a comparison of the two modern methods of machine operation, it might be well to summarize the advantages of each as follows:

Group Drive.—Reduction of first cost of tools and motors of about 15 per cent.

Independent Drive.—Increased output. Saving in fuel due to the elimination of frictional losses in shafting, belting, etc. Saving in labor by obviating the necessity for shifting belts, lacing belts, repairing friction pulleys on countershafting, etc. Reduction in the size of power plant required by reducing frictional losses. Ability to place any machine where desired, fric- out reference to shafting or crane locations. Increased light, due to the elimination of shafting and belting. Elimination of shafting and belting maintenance cost. The ability to operate a single machine overtime without the necessity of operating any other machine.

Alternating Current vs. Direct Current

It might be well to state the relative merits of alternating and direct current for operating motors in railroad shops. Probably 75 per cent of the power required will be for the operation of constant speed machinery and lights. The department requiring the most power is the one in which woodworking machinery is placed, this machinery invariably operating at constant speed.

The simplest form of alternating current motor, namely, the induction type, with squirrel cage winding, is essentially a constant speed machine, entailing low maintenance charges and being designed and constructed for constant speed work. This type of motor is well adapted for the operation of all constant speed machines, such as woodworking shop machinery, blacksmith shop machinery, boiler shop machinery, boring mills, planers, small lathes, etc. It has been demonstrated that slip-ring induction, alternating current motors provide a satisfactory means for operating cranes, transfer tables, turntables, hoists, etc. However, where we have to contend with variable speed machinery such as wheel lathes, large axle lathes, direct connected reversing planers, etc., requiring a wide range of speed, the best results would be obtained by the use of direct current motors with field control. With this type of motor any speed variation up to and including a ratio of 4 to 1 may be obtained.

Power Plant

The construction of a power plant, upon the efficiency and reliability of which the operation of the shops as a whole is primarily dependent, great care should be exercised in the selection of the machinery, both as regards to quality and design, in order that it may be best adapted for the service required.

In a great majority of shop installations, a most satisfactory arrangement may be obtained by using alternating current turbo-generators as probably about 75 per cent of the total power requirements will be for constant speed machinery and lights for which alternating current is suitable. The direct current necessary can then readily be supplied from a motor-generator set, composed of direct current generators driven by synchronous motors. Such motors, in addition to furnishing power to drive the direct current generators, can then be utilized as phase modifiers to improve the power-factor of the system, which, due to the operating conditions of most railroad shops is about 70 per cent or less. A hard and fast rule in engineering can hardly be set down for all cases, but the arrangement, as above outlined, will, in nearly every instance, prove most economical, both from a standpoint of first cost and operating expense.

Motor Maintenance

All motors, whether operating continuously or partially, should be looked over at least once each day by a competent man under the supervision of the Electrical Department. It should be his duty to inspect all connections, see that bearings are properly lubricated, see that brushes are properly seated, see that commutators are clean and smooth and see that motors are kept free from dust, dirt and grease. All motors should be thoroughly cleaned and if possible blown out with compressed air at regular periods, at which time air gaps should be gaged. There does not seem to be any standard rule covering this work, as each road usually works out these details according to its own ideas.

Motor Repairs

Each railroad, if possible, should maintain at least one adequate repair shop to handle electrical repairs, as the time required to transfer material to be repaired to and from outside repair shops necessitates the carrying in stock of additional spare motors, transformers, etc., to take the place of those being repaired.

Maintenance and Repairs of Direct Current Equipment

The most important factors in the maintenance and repairs of direct current equipment are cleanliness and regular, thorough and intelligent inspection. Most cases of trouble in this type of apparatus can be traced to both dirt and neglect. When a generator or motor is not regularly blowed or wiped out, and brushes, holders and commutators thoroughly cleaned, bad sparking at the brushes is nearly always the result, and frequently serious damage to equipment is thus caused. To get the best results with the lowest cost for repairs, direct current apparatus should be inspected regularly at least once each day by a competent electrician. If this be done many minor cases of trouble will be detected and corrected which otherwise might become worse and cause serious damage.

Sparking at the brushes is probably the one trouble a repair man is most frequently called upon to correct and it is generally caused by the following: Brushes not set diametrically opposite, not at the neutral point, too hard, too much lubricant, do not have proper contact, not in line, cover too many or not enough segments, have not proper carrying capacity, high commutator bars, high mica, commutator rough or eccentric, open, short circuited reversed or grounded armature or field coils, etc. It is sometimes the case, though infrequently, that the machine is improperly wound, or has not the required amount of iron in the core. Dirt is a very great factor in many of the above given causes of sparking, and when allowed to accumulate, causes grounds, short and open circuits, and rough commutators.

Heating in a machine is caused by any one or more of the above causes of sparking, also by overload, moisture in coils, hot bearings, etc. Such minor troubles, when neglected, greatly increase maintenance and repair costs and are some of the reasons a system of regular and thorough inspection is necessary to obtain good results and efficient operation with direct current equipment.

Electrical Repair Shop

In the average railroad shop, having electrically-driven machines, the cost of repairs to electrical equipment can be considerably decreased by maintaining a repair shop in which winding of armatures, field coils, and all the miscellaneous repairs in connection with the equipment can be made, instead of having them done by outside shops. For a nominal sum a shop can be equipped with all the necessary tools and apparatus for making and forming armature coils, rewinding field coils, turning down commutators, balancing and baking armatures, etc. In one instance where identical repairs were made to two machines of the same size and type, the railroad shop did a far more substantial job than the outside shop did at a cost approximately 35 per cent less. In addition to the money saving, the time saved in making repairs, and the consequent saving in loss of production are important factors in favor of an electrical repair shop. In addition to the larger repairs on motors and control apparatus the repair shop saves considerable money by refilling fuses and putting in a usable condition such material as cutouts, switches, etc., that would otherwise be scrapped.

Types of Motors

For operation on constant potential, where constant speed is required from no load to full load, and where the starting load is light, the shunt-wound motor is best adapted, as its speed is practically constant for any load. However, the speed of a shunt-wound motor can be varied over a wide range by varying the voltage at the brushes or the strength of the field or armature, but when the speed is once adjusted it remains practically unaffected by a change of load. For these reasons shunt-wound motors are desirable for use in connection with lathes, boring mills, fans, blowers, line shafts driving small machine groups, bolt cutters, chucking machines, grinders, drill presses, small boring machines, milling machines, saws, sanders, motor-generators and pumps, except where starting conditions are severe.

Compound-wound motors are best adapted for service where large starting torque and nearly constant speed are required. The speed of this type of motor can also be varied considerably by varying the strength of either the shunt or series field. This type of motor is best adapted for use in connection with all machines having a reciprocating motion, heavy line shaft drive, planers, slotters, bulldozers, shapers, tumbling mills, bolt and rivet headers, pipe machines, punches, shears, rolls, drop hammers, all machines subject to sudden and intermittent loads, and on practically all wood working machines, as the high friction in this class of machinery is a great hindrance in quickly bringing it up to speed. Compound-wound motors will develop higher starting and maximum torques with the same current input than shunt-wound motors, but while operating their speed will vary more with the load. They should be used where high starting effort with low current consumption is desired and slight change of speed with change of load is not objectionable, also on circuits where the voltage fluctuates, as in this latter case, the series winding helps to steady the current and speed.

Series-wound motors have a very powerful starting torque and are used in connection with machines where speed regulation is not essential, such as cranes, hoists, transfer tables, telpher systems used for handling logs, lumber, coal, etc. This type of motor must always be either geared to, or direct connected with, the machine, as the breaking of a belt or sudden removal of load causes the motor to race and seriously damage itself. The series-wound motor develops higher starting and maximum torque with a given current than either the shunt or compound-wound types, but while operating its speed varies greatly with the load.

Commutating pole or interpole motors and generators are preferable in all classes of service. With this type of motor, commutation is practically perfect, the commutating pole producing within the armature coil under commutation, an e. m. f. of the proper value to completely reverse the current in the coil while it is still under the brush.

Enclosed type motors should not be used unless absolutely necessary, as they are very inefficient and give constant trouble.

There is very little reliable data on the relative costs between individual and group drive, as conditions in various shops widely differ. The saving of power is not the most important result of individual drive if the cost of oiling, repairs to line shafts, belting, and the time lost by machinists during breakdowns are considered. In two cases, one where machines were grouped and driven by one motor, the other where the same number, sizes and kinds of machines were installed with individual drive, the costs have been accurately kept. The cost of the group-driven installation was approximately 88 per cent of the cost of the individual drive installation. The horse-power required for the group-driven machines is .71 per cent of that required to drive the same machines with individual motors, but the cost of maintenance and repairs for the individual drive installation is from 75 per cent to 100 per cent cheaper. The difference in cost of group and individual drive installation is saved in from two to three years, when saving in power is considered, and when saving is considered from a production standpoint, the difference in cost is saved in a very short time. The power lost in friction, shafting, belting, etc., in group drive will vary between 25 per cent and 40 per cent, and in some cases it has been known to run as high as 60 per cent, while the total power loss in individual drive is seldom greater than 15 per cent. The saving in power consumed and the cost of maintenance are the two principal points in favor of individual drive; however, the loss in production and of men's time, when a line shaft motor fails, should not be lost sight of as another point favoring individual drive. Local shop conditions, cost of operation and class of work to be done are always determining factors in deciding upon the kind of installation, much thought should be given on these matters before a decision is made.

Motors can be direct connected, belted, geared, or connected by chain drive to machines, but the least expensive and most convenient method is belt-drive. The success of a belted motor depends largely on the arc of contact, distance between pulley centers of motor and machine, and speed reduction. When very low speeds are necessary back-geared motors should be used.

The cost of a motor increases as the rated speed decreases, consequently it is always desirable to use as high a speed motor as possible in order to keep the cost of installation down to a minimum.

Modern practice is to standardize the speed of motors, and rated speeds from 900 r. p. m. to 1200 r. p. m. are rapidly becoming standard.

The selection of generators for any class of service is generally a matter of choice between the different makes. For power purposes the 250-volt, compound-wound, interpole generator is generally conceded to be the most desirable. When power and light are both to be supplied by one generator, the three-wire type is desirable, as with this type of generator both 110 volts for lighting and 220 volts for power are obtainable. Direct connected generators are always preferable, although good results are obtained with the belted types.

Maintenance of Illuminating Equipment

The best methods of maintaining illuminating equipment and the resultant maintenance costs depend primarily on the individual installation. Numerous systems are being maintained which should be scrapped and replaced by a more suitable and efficient installation, which is not done because illumination has been difficult for the practical man to measure and figure in dollars and cents. He knows what it costs to install and maintain a system, but does not know what returns to credit. Not knowing actually what the benefits derived are worth, it is difficult to know when to install a new system or when to spend more money for maintaining an existing system to a higher standard.

It is safe to say that the value of illumination is very seldom overestimated. We are used to getting daylight for nothing, hence the reason why the cost of artificial light often appears so high. In modern industrial plants it is considered good practice for the cost of light to equal .5 to 1 per cent of the total wage. In most railway shops, roundhouses, etc., where the number of workmen per unit area is small this should run close to 1 per cent. This does not appear so high when we consider that only four minutes of the average workman's time costs the same amount as the illumination of his work for an eight-hour day. How easy it is for him to lose four minutes' time in a day on account of needing a little more or better directed light. Before going further into the maintenance methods and costs we will briefly outline and classify the best types of lamps for various purposes.

General Comparisons of Lamps and Systems.

In designing an illuminating system, the first consideration is the intensity of illumination needed. We will not dwell on this since there is much readily available data on the subject, which is sufficiently accurate for the ordinary classes of work.

Next, coupled with the problem of light distribution and direction, comes that of selecting the best unit. Since the discussion is limited more to industrial lighting, decorative features, etc., are not to be considered. In the railway shops, yards and terminal buildings the object is to supply sufficient light with the best possible distribution. To select the most desirable

TABLE III

Type of unit		750 watt quartz	1,000 watt gas filled in porcelain enameled reflector
Total effective lumens		12,500	13,400
Total initial cost of unit		$60.00	$10.00
Annual fixed charges.			
Insurance	0.25%	$0.15	$0.02
Taxes	0.40%	.24	.04
Interest on total investment	5%	3.00	.50
Depreciation on parts not renewed	10%	4.50	.40
Monthly cleaning		.75	.75
		$8.64	$1.71
Maintenance cost per year 4,000 hours		20.00	20.00
Energy delivered to lamp at $0.02 per kw. hour.		60.00	80.00
Total annual operating cost		$88.64	$101.74

unit we balance the total annual operating costs with the individual features, such as color, flexibility, size of unit, and other items which may have advantages or disadvantages peculiar to a certain building or class of work. The data in Table III are approximate figures for total annual operating costs of a 1000-watt gas-filled unit and a 750-watt quartz lamp.

Here it will be seen that the largest item of the total annual operating cost is the cost of energy consumed, in fact this will average about 75 per cent of the total. Hence the efficiency of the unit is of first importance. The efficiency is best expressed in lumens (or any unit of total light flux) per watt. Reliable data on relative efficiencies of illuminants is scarce. Manufacturers rate their lamps either in lumens, mean horizontal candle power, mean spherical candle power, or mean hemispherical candle power, and with or without reflectors, globes, etc. This data cannot be used to compare efficiencies until reduced to a common unit and compensated for losses incurred by necessary reflection. Table IV. is an attempt at a true comparison of efficiencies of a few lamps. The data was compiled by reducing to lumens and averaging varying values obtained from several sources.

TABLE IV

Description of lamp	Amps.	Volts	Watts	Initial lumens per watt: As in description	Initial lumens per watt: With shallow bowl porcelain enameled reflector
D. C. open carbon arc	9 6	47	450	10.2	8.0
D. C. enclosed carbon arc clear inner globe, no outer globe	6.5	115	...	5.5	4.4
D. C. enclosed carbon arc opal inner, clear outer globe	6.5	115	...	4.3	3.4
D. C. luminous arc, clear globe internal reflector	6.5	115	...	13.0	11.7
D. C. enclosed flame arc, clear inner, opal outer globe	6.5	115	...	16.8	13.4
A. C. enclosed carbon arc clear inner opal outer globe	...	115	430	4.2	3.2
Mercury arc, tube with reflector—21 in.	3.5	55	192	11.2	11.2
Mercury arc, tube with reflector—45 in.	3.5	110	385	13.5	13.5
Mercury arc, Quartz internal reflector and outer globe	3.3	230	...	18.6	16.7
Vacuum tungsten clear	...	115	100	10.1	8.0
Vacuum tungsten clear	...	230	100	9.4	7.3
Vacuum tungsten clear	...	230	250	10.4	8.3
Gas filled tungsten clear	...	115	100	12.6	10.0
Gas filled tungsten clear	...	115	200	13.3	10.7
Gas filled tungsten clear	...	115	400	14.4	11.5
Gas filled tungsten clear	...	115	750	15.5	12.3
Gas filled tungsten clear	...	115	1000	16.8	13.4
Gas filled tungsten clear	...	230	200	12.0	9.6
Gas filled tungsten clear	...	230	400	13.2	10.6
Gas filled tungsten clear	...	230	750	13.9	11.1
Gas filled tungsten clear	...	230	1000	13.8	11.0
Street series gas filled	5.5	13	...	13.9	11.1
Street series gas filled	7.5	21	...	16.9	13.6
Street series gas filled	15.0	13	...	20.3	16.0
Street series gas filled	20.0	22	...	22.4	17.8

Distribution System

The maintenance of the distribution system includes that of the panels and circuits to the terminals of the units. This is such a varying quantity that little concise data is available. If the wiring were installed in a first-class conduit system and circuits not overloaded the maintenance would be very low up to the time the system would be renewed for other reasons. Except for an occasional run of wire necessary on account of accident, defective material or workmanship the only other items will be burned fuses, switch contacts, etc.

Regarding the advisability of painting conduit regularly with a preservative compound, this is not firmly established. Conduit in a roundhouse if not painted will last approximately 10 years. By this time it is probably time to install an entire new system, due to changes in the art, construction of the building, or requirements of the service. Even if the conduit is regularly cleaned and painted, the chances are that the parts in corners and small clearances where most dirt and acid accumulate will be slighted. The distribution maintenance will vary somewhat in proportion to its use, hence the reason why this item was included in the energy cost of Table III. In the average railway shop this yearly maintenance should not exceed 2 per cent of the initial cost of installation, nor 2.5 per cent of total energy used at $0.02 per k.w. hour.

Illuminating Units

Following is a list of the several units which are competitors for this class of service. The maintenance of each is made up of the respective sub-items.

1 and 2. Luminous and flaming arcs.
    a—Keeping mechanism in working order.
    b—Trimming.
    c—Cleaning globes and reflectors.

3. Mercury arcs.
    a—Repairs to lamp mechanism.
    b—Occasional renewal of burners.
    c—Cleaning globes and reflectors.

4. Tungsten lamps in porcelain enameled steel and aluminized reflector.
    a—Occasional repairs to sockets and holders.
    b—Lamp renewals.
    c—Cleaning lamps and reflectors.

On account of the reliability, low first cost, simplicity, and ease of maintenance the tungsten units have the most general use in railway shops. Therefore only this type of unit will be further considered. However much of the following discussion such as accessibility to lamps, and methods of cleaning also applies to other types.

The standard of cleanliness for lamps and reflectors should depend on a balance between the cost of cleaning and loss by not cleaning. The cost of each cleaning will depend materially on the method used, and on the accessibility to the units. The following are several general methods which may be used in shop buildings for gaining access to the lamp: (1) From a step ladder where the units are hung close enough to the floor. (2) By lowering units to floor by the use of a rope and automatic cut-out hanger. (3) From the trolleys in traveling crane bays. All these methods have their objections. The long step ladder is difficult to handle, shaky to work on, especially where it is liable to be hit by push carts and trucks. It is also hard to place among machines, belts, and material piled about the floor. The use of the automatic cut-out hanger adds materially to the cost of construction, but it is the only method satisfactory in many places. Access to lamps from traveling cranes requires that the work be done outside of regular shop hours and in many cases requires the use of higher priced labor or the extra cost of a regular operator for the crane.

After gaining access to the lamp, the following points must be considered: (1) Shall the entire unit be cleaned in place, (2) shall the lamp be removed and cleaned on ladder or crane, reflector cleaned in place, or (3) shall the lamp, reflector or both be removed and carried to a shop for cleaning. The first method is preferable because there is less risk of breaking lamps, but it is applicable only when a shallow reflector is used, and even then it is difficult to be sure that all sides of the reflector and lamp are clean. The second method is best in most cases. If the work is being done on top of a crane trolley proceed as follows: Remove lamp, clean and place in a special padded box, clean reflector in place or by removing if easier, then replace lamp, being careful to screw in snug, but not so tight as to break or loosen the base. The third method of removing the complete unit and carrying to a shop to clean is more costly but advisable in certain cases where conditions on the floor below the lamp do not permit the work being done there.

For cleaning, the use of the following is recommended: (1) soap and water, (2) gasoline or benzine, (3) denatured alcohol, (4) ammonia. For ordinary conditions soap and hot water will thoroughly clean the lamps and reflectors. However, in most railway shop buildings where smoke and oily fumes are present it is necessary to use some of the latter. Denatured alcohol will cut the dirt much quicker and better than gasoline and less is required per lamp. Although it costs approximately $.35 per gallon as against $.18 for gasoline it is cheaper to use. One gallon of alcohol will clean 90 750 watt units with 18-in. bowl reflectors. A small piece of waste dampened with alcohol is followed by a handful of dry waste. Such solutions as gasoline or alcohol should not be used on aluminized reflectors. For these the manufacturers recommend only soap and water or a very weak solution of ammonia.

It has been found to require approximately six minutes per unit to thoroughly clean a 750 watt lamp and an 18-in. porcelain enameled steel reflector, from a crane trolley, this not allowing for the time necessary to move the crane to new positions. In a reasonably busy shop this must be done on overtime, and in many cases it will pay to provide a regular operator to move the crane. If the cleaner operates the crane the total cost is approximately $.75 per unit per year for monthly cleaning. If two men are necessary this figure is raised to $1.20 per unit. Small 200 watt units in bowl reflectors can be cleaned from a step ladder for $.30 to $.50 per year.

From the above figures and those in Table III, it will be seen that this monthly cleaning is a very small per cent of the total annual operating cost. This cost of monthly cleaning for the 1000 watt unit is .75 per cent of the total.

Referring to Fig. 6, the area of the shaded rectangle represents the total annual operating cost of a 1000 watt gas filled lamp in a porcelain enameled steel reflector. The darker shaded area below the curve represents the loss by reduction of useful light on account of the accumulation of dirt for one year. This curve was plotted by converting to dollars for this size unit, an average of available data on this decrease of efficiency. The curve will hold good for the average railway shop building. There are places where this amount of dirt will accumulate in one month, and other locations where much less will accumulate. The rate of loss after an elapsed time is read direct from the corresponding points on the curve. In this specific case the loss at the end of 12 months without cleaning is at the rate of $34.00 per year, while the loss incurred during the year is approximately $22.00. At the end of the first month the loss is at the rate of $9.00 per year and the loss incurred during the month $4.50. Subtracting the $4.50 from $22.00 leaves $17.50 which could be spent for monthly cleaning which costs less than $1.00. The remaining $16.50 is actually 1650 per cent interest on the money spent for cleaning.

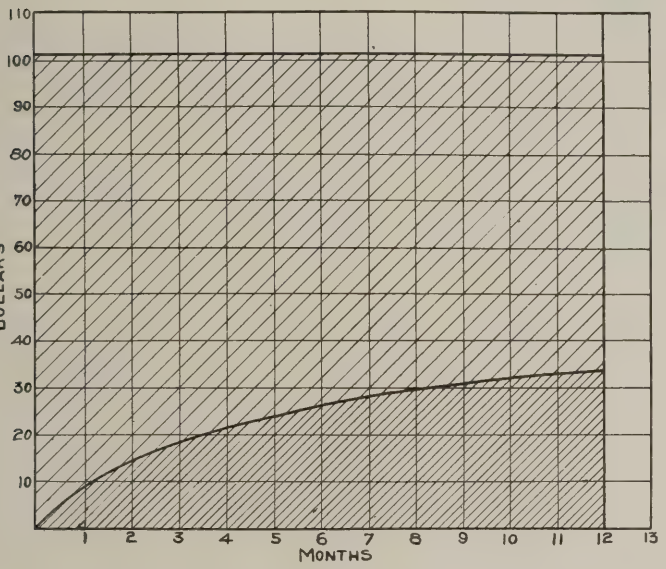


Fig. 6—Total Annual Operating Cost, and Loss by Not Cleaning—1,000-Watt Gas-Filled Lamp in Porcelain Enameled Reflector

In many buildings it is a very good investment to keep the walls and ceilings painted white. This is especially true where the ceilings are moderately low and in building bays adjacent to the outer walls. In such places it is safe to say that the illumination may be increased 25 per cent by painting white. If sufficient illumination initially costs .8 per cent of the total wage, then 25 per cent of .8 per cent, or .2 per cent, can be expended each year for painting, this figuring the benefits to artificial lighting alone. Cold water paint is inexpensive and can be applied with relatively cheap labor. In many shops the walls and ceiling are now being painted white but not regularly, nor nearly as often as they should be. The white walls and ceiling are a part of the illuminating system. When an installation is made the color of the walls and ceiling is taken into account, but often forgotten when the system is in service. The maintenance should include all such items in money value for the specific conditions.

Sub-Committee: J. H. Wickman, Illinois Central, chairman; J. H. Edwards, Chicago, Rock Island & Pacific; J. H. Wright, Chicago, Burlington & Quincy; J. C. McElree, Illinois Central.

Car Lighting Hand Book

In compliance with instructions of the executive committee to prepare a handbook covering the maintenance of electrically equipped cars, your committee has formulated a preliminary set of rules for this purpose; the object of the committee is to have these rules thoroughly discussed and to receive suggestions and criticisms to the end that the rules may be perfected and printed in book form for distribution to the membership.

The executive committee is of the opinion that a set of rules of this kind, based on actual practice, will not only be beneficial to the new man entering into car lighting work, but will be of general good use to all interested.

Committee: E. Wanamaker, Chicago, Rock Island & Pacific, chairman; E. S. M. Macnab, Canadian Pacific; A. Voigt, Atchison, Topeka & Santa Fe; C. J. Causland, Pennsylvania.

Train Lighting Equipment and Practices

Your committee, appointed to consider the revision of present adopted recommendations for standards, has held several meetings both as members of the committee as well as members of the M. C. B. Train Lighting and Equipment Committee and submitted a progress report at our last semi-annual convention at Atlantic City.

In view of the fact that their recommendations to the M. C. B. Association were not submitted to letter ballot until August 21, 1916, the result of the letter ballot was to be counted on September 20, 1916. The chairman did not feel justified in calling a meeting of your committee until after the results of the letter ballot of the M. C. B. were published. We, therefore, resubmit our progress report as an annual report of the committee for such action as our members may wish to take.

The committee would recommend, however, that the recommendations for standard practice submitted to the M. C. B. Association at the 1916 convention be ratified, and such changes be made in our present recommended practice as will make them conform to the recommendations submitted to the M. C. B. Association at its June convention of 1916, which are as follows:

The Committee on Train Lighting and Equipment has completely revised these Recommended Practices by (a) eliminating certain features, (b) adding necessary matter, (c) regrouping, (d) rewording certain sections, and (e) otherwise rearranging subject matter. The revised rules are herein given in full, but a vote is asked for only on such paragraphs where important changes, etc., in the rules are involved.

1. *General.*—System Voltages:

(a) That in electrically lighted cars the following voltages should be used:

(b) Sixty volts (nominal) for straight storage and head-end systems.

(c) Thirty volts (nominal) for straight storage and axle-generator systems. (Individual cars.)

Inasmuch as only about two per cent of the cars lighted with individual axle generators are equipped with 60-volt system, and as such voltage requires a battery of twice the number of cells, also a decreasing tendency in the use of equipment of this voltage for application to individual cars, it is felt that further use of this system should no longer be recommended.

2. *General.* — Descriptive Notices. — That each electrically lighted car in steam service shall be provided with a notice located in or near the switchboard locker as follows:

A B & C Railroad.

Description of Electric Light Equipment.

This car is lighted by .... V .... System.

	Gen.	Gen. Reg.	Lamp Reg.
Make			
Type			
Set for volts—max			
Set for V. floating			
Set for amps. batty			
Set for amps.—max.			

Pulleys.—Axle.....in. dia......in. face; .....in. depth of flange.
Armature........in. dia. ....in. face.
Belt.—Length........ft. ....in. Width........in.
Battery.—No. cells on car........; No. sets in parallel........
Amp. hr. capacity each set at 8 hr. rate ....
Charging current each set.........normal, ...max.
Lamps.—Voltage............
Load.—Lights (including fans) ....amps.
Battery............amps.
Total.............amps.
Train Line Wires.—No........(2 or 3). Size........A. W. G.

The above changes are suggested with a view to giving additional necessary information and placing the same in appropriate form.

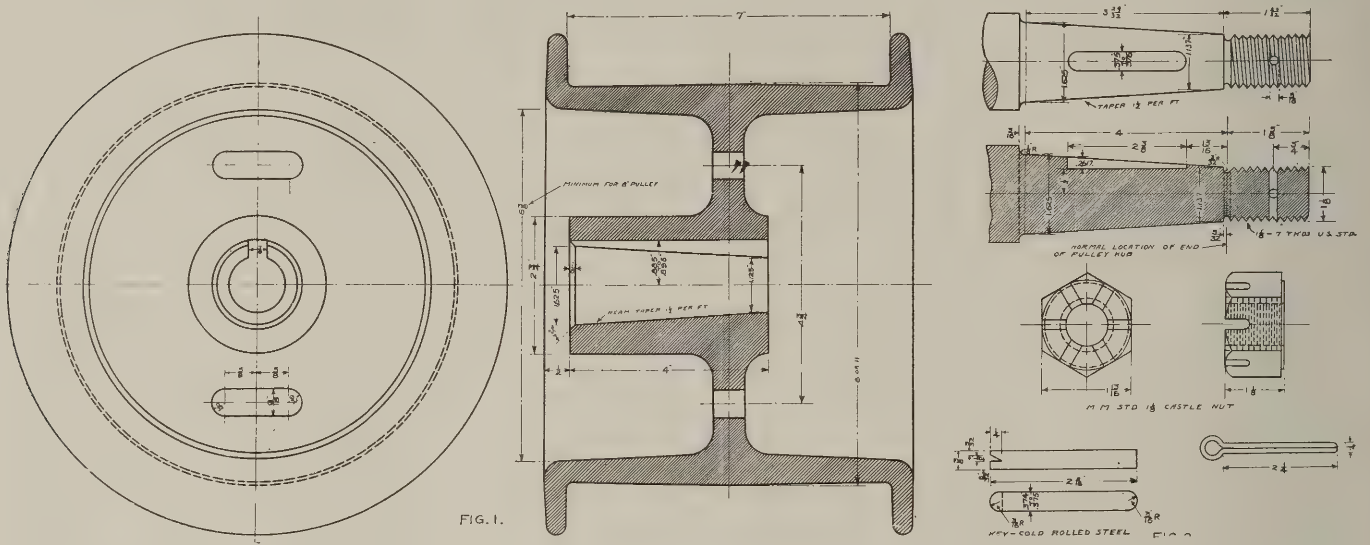


Fig. 1 and 2—Armature Pulley, Pulley Seat, Key, Nut and Cotter for Pulleys Eight Inches or Larger Diameter, For Ball Bearing Generators

3. *Clearances.*—(a) The axle-generator suspension shall be so designed that with car on straight, level track the clearances shall be as great as possible but not less than those specified below:

(b) From any part of the generator or suspension to the rail....................6 in.

(c) On truck-suspended generators from any part of the generator or suspension to the car body or any part attached thereto....................3½ in.

(d) With all parts of the car and axle generator, affecting the clearances, in the same condition as when new, with the minimum belt tension to drive load and with the generator in any service position with respect to the suspension and with the truck in any service position with respect to the car body, the clearance from any part of the belt to

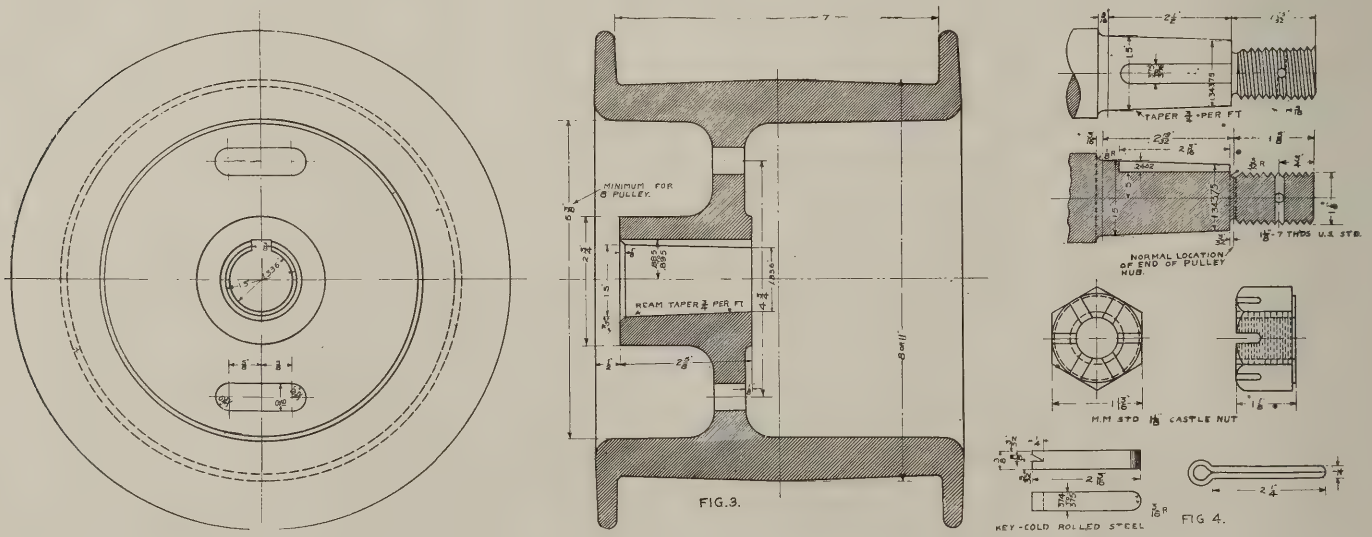
	End Sill.		Brake Beam.		To any other part car body or truck.
	Over.	Under.	Over.	Under.	
Truck supported........	1 in.	1½ in.	2½ in.	1 in.	½ in.
Body supported	1½ in.	1½ in.	3 in.	1 in.	1 in.

(e) With any or all parts of car and axle generator worn to the allowable limits and other conditions the same as in paragraph (d), from the belt to any part of the truck or car body, ... ½ in.

Note.—As the question of obtaining the above clearances is essentially a problem of car and truck design it is recommended that all car designers pay special attention to this feature. The chairman of the M. C. B. committee has been instructed to take this matter up with the other M. C. B. committees interested.

The above was drawn up with the idea of including all necessary clearances and grouping them under one heading.

(1) Do you approve of the recommendation?



Figs. 3 and 4—Armature Pulley, Pulley Seat, Key, Nut and Cotter for Pulleys Eight Inches or Larger Diameter, For Sleeve Bearing Generators

4. *Generator.*—Suspensions.—(a) In axle-generator suspensions, all supporting parts subject to wear shall have the wearing surfaces bushed.

(b) All axle generators shall be provided with safety chains or an equivalent construction which will safely support the generator in case of failure of the suspension.

(c) In truck-supported axle generator suspensions, if side arms be used, the end to be secured to the truck frame shall extend under the transom and be secured to the side frame near the transom and shall be securely attached to the end sill by a U-bolt not less than ¾ in. in diameter, or a construction equivalent in strength.

Reworded to make the meaning clear and additional features to provide for greater safety.

(2) Do you approve of the recommendation?

5. *Generator.*—Mounting.—When facing the end of the truck on which the axle pulley is mounted, the generator pulley or sprocket shall preferably be on the right of the generator.

Reworded to provide for body-suspended generators.

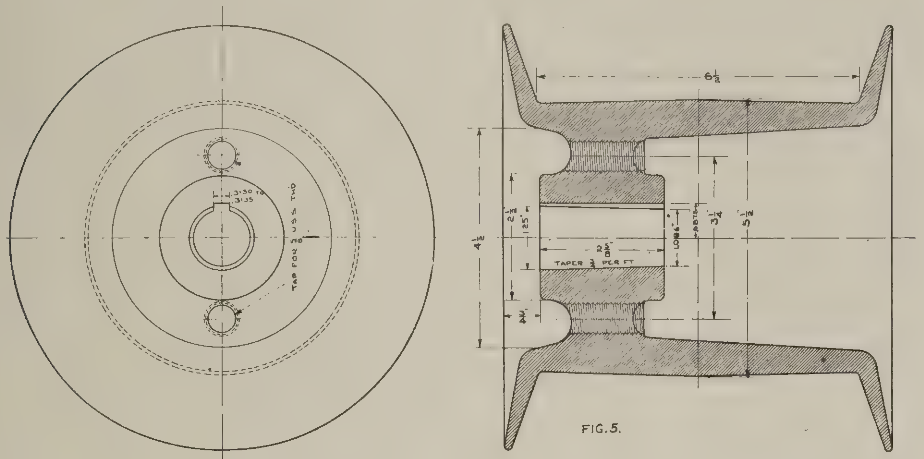


FIG. 5.

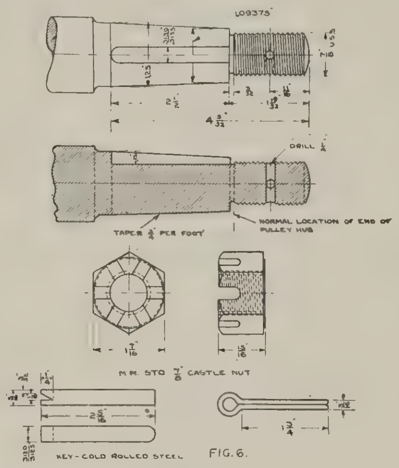


FIG. 6.

Figs 5 and 6—Armature Pulley, Pulley Seat, Key, Nut and Cotter for Armature Shaft 1¼ in. Diameter

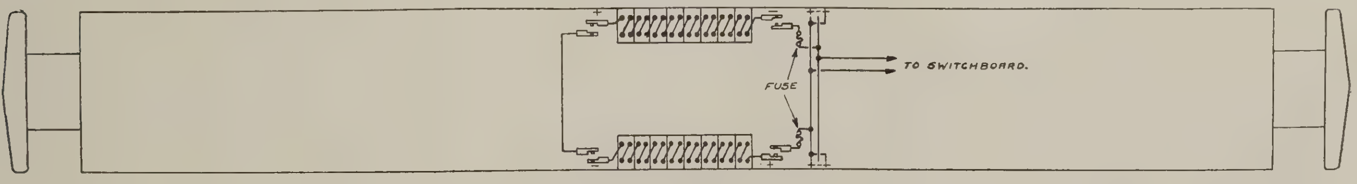
6. *Generator.*—Axle Pulley and Bushing.—(a) A straight pulley seat shall be provided for the axle pulley.

(b) If a bushing be used it shall preferably be secured to the axle independently of the pulley and have an external diameter throughout its length of 7½ in. and be not less than 8½ in. long.

(c) The hub of the axle pulley shall have a uniform internal diameter of 7½ in.; the length of the hub shall be 6½ in.

(d) The face of the axle pulley shall be not less than 9 in. if flangeless, and not less than 8 in. if flanged.

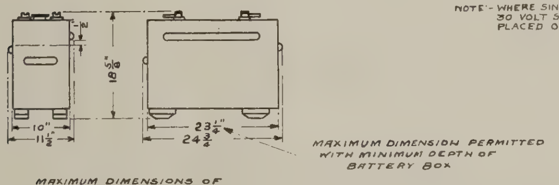
(e) The diameter of the axle pulley shall be as large as the construction of the car will permit, preferably 21 in. or 17 in.



METHOD OF CONNECTING SET OF BATTERIES TO CAR WIRING.

NOTE:- WHERE SINGLE SET OF BATTERY IS USED FOR 30 VOLT SYSTEM ALL CELLS SHOULD BE PLACED ON SAME SIDE OF CAR.

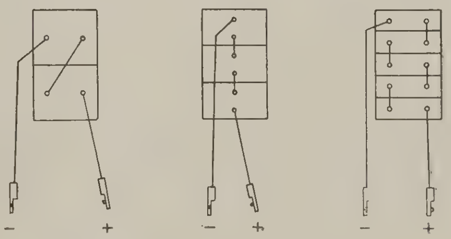
FIG. 7.



18⅝"
10"
11½
23¼"
24¾
MAXIMUM DIMENSION PERMITTED WITH MINIMUM DEPTH OF BATTERY BOX

MAXIMUM DIMENSIONS OF BATTERIES ASSEMBLED IN TRAYS

FIG. 8.



METHOD OF CONNECTING CELLS OF BATTERY ASSEMBLED IN ONE TRAY

FIG. 9.

Figs. 7, 8 and 9—Storage Battery—Dimensions of Trays and Method of Connections

Regrouping of subject matter.

7. *Generator.*—Armature Pulley.—(a) The armature pulley shall be flanged and crowned, with a 7-in. face and a diameter of preferably 8 in. or 11 in.

(b) On all ball-bearing axle generators having armature pulleys 8 in. in diameter or larger, the armature pulley shall be in accordance with the dimensions as shown on Sheet A, Fig 1.

(c) On all sleeve bearing axle generators having armature pulleys 8 in. in diameter or larger, the armature pulley shall be in accordance with dimensions as shown on Sheet B, Fig. 3.

(3) Do you approve of the recommendation in paragraph (c)?

(d) On all axle generators having armature shafts less than 1½ in. in diameter at inner end of pulley seat, the armature pulley shall be in accordance with dimensions shown on Sheet C, Fig. 5.

Regrouping of subject matter and the addition of pulleys for generators having shafts less than 1½ in. in diameter, due to development of light-weight body-suspended generators.

(4) Do you approve the recommendation in paragraph (d)?

8. *Generator.*—Armature Pulley Seat.—(a) On all ball-bearing axle generators having armature pulleys 8 in. in diameter or larger, the pulley end of the armature shaft, the nut, key and cotter pin shall be in accordance with the dimensions as shown on Sheet A, Fig. 2.

(b) On all sleeve bearing axle generators having armature pulleys 8 in. in diameter or larger, the pulley end of the armature shaft, the nut, key and cotter pin shall be in accordance with the dimensions shown on Sheet B, Fig. 4.

(c) On all axle generators having armature shafts less than 1½ in. diameter at end of pulley seat, the pulley end of armature shaft, the nut, key and cotter pin shall be in accordance with the dimensions shown on sheet C, Fig. 6.

Regrouping of subject matter and the addition of pulley seats for generators having shafts less than 1½ in. in diameter due to development of light-weight body-suspended generators.

(5) Do you approve of the recommendation in paragraph (c)?

9. *Generator.*—Ball Bearing, Size of.—On all truck-supported ball-bearing axle generators, the bearing shall be the size known commercially as No. 412.

To clarify meaning.

10. *Batteries.*—Boxes, Design of.—(a) Battery boxes shall

have interior dimensions at least as great as those given below.

Height in clear, 21½ in.

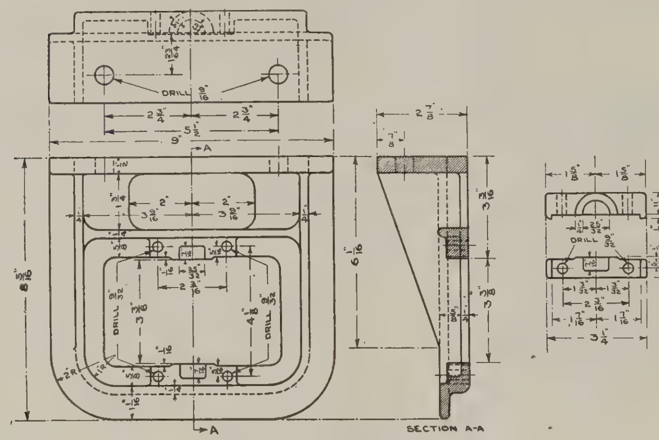
Depth, front to back, 2 ft. 1 in.

Length of compartment to hold two standard double compartment trays, 22⅝ in.

Length of compartment to hold four standard double compartment trays, 3 ft. 9¼ in.

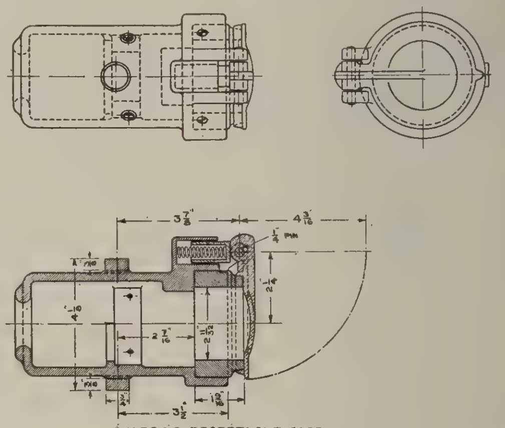
(b) Battery boxes with two compartments, each 22⅝ in. long, or with one compartment 3 ft. 9¼ in. long shall be designed to carry a battery weight of not less than 1600 lb.

(c) Battery boxes with four compartments, each 22⅝ in. long, or two compartments, each 3 ft. 9¼ in. long, shall be designed to carry a battery weight of not less than 3200 lb.



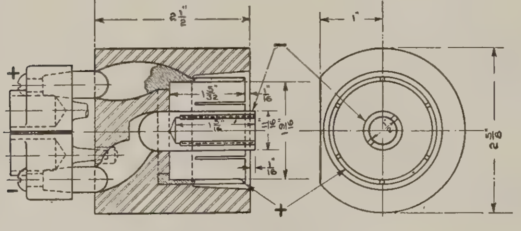
SWIVEL SUPPORT TO CARRY CHARGING RECEPTACLE CASE FIG 11

FIG. 10.



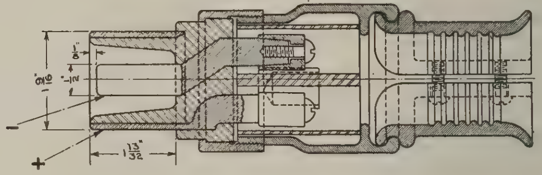
CHARGING RECEPTACLE CASE TO TAKE INTERNALS FIG 12

FIG. 11.



"INTERNALS" FOR CHARGING RECEPTACLE CASE FIG 11

FIG. 12.



CHARGING PLUG FOR USE WITH INTERNALS FIG 12

FIG. 13.

Figs. 10, 11, 12 and 13. Charging Plug and Receptacle, Receptacle Case and Swivel Support

(d) That in all battery-box designs two angle irons or straps shall extend longitudinally under the battery box located so that in case of a defective battery-box floor, the trays will be supported by the said angle irons or straps. The angle irons or straps shall be attached to the car body independently of the battery box and shall be of sufficient strength in all parts to safely support the weight of battery as given in paragraphs 10 (b) and (c); plus the weight of the battery box. The angle irons or straps shall be so installed that they can be readily inspected. A construction equal to the above in strength and safety will be allowed.

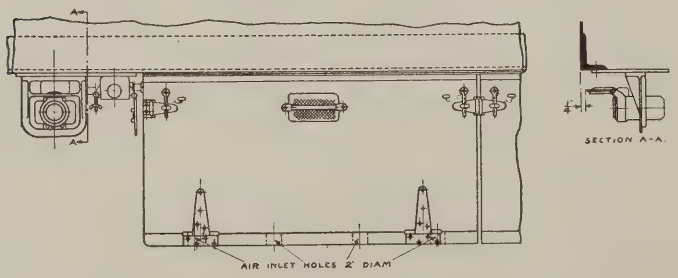


FIG. 14.

Fig. 14—Relative Location of Charging Receptacle, Battery, Fuse Box and Battery Box

To clarify meaning.

11. *Batteries.*—Boxes, Ventilation of.—(a) Each battery box shall be provided with adequate ventilation as follows:

(b) Inlet openings located on the longitudinal center line of the floor of the battery box having a combined area of approximately 6 sq. in. for each 22⅝-in. compartment.

(c) Outlet openings located near the top of the battery box having a combined area of approximately 6 sq. in. for each 22⅝-in. compartment.

To provide a suitable method for adequate ventilation.

(6) Do you approve of the above three suggestions?

12. *Batteries.*—Trays, Dimensions of.—Storage batteries for car lighting service shall be assembled in trays whose maximum dimensions shall not exceed those given on Sheet D, Fig. 8, when used in battery box having minimum dimensions given in paragraph 10 (a).

Elimination of details of battery construction not essential to interchangeability and providing such dimensions as are necessary for interchangeability.

(7) Do you approve of the above suggestion?

13. *Batteries.*—Connection for.—(a) That where two or more cells are assembled in one tray, the connections and arrangements of battery terminals shall be as shown on Sheet D, Fig. 9.

(b) The connections between the terminals of the battery and car wiring shall be made with a connection as shown on Sheet D, Fig. 7.

(c) When the Westinghouse type connector is used to connect battery to car wiring it shall be installed as follows: At the positive terminal of the battery, the male end of the connector shall be attached to the positive battery terminal lead and the female end to the car wiring. At the negative terminal of the battery, the reverse connections shall be made.

(d) That each set of batteries shall be connected so that, facing the battery box, the positive terminal is at the right as shown on Sheet D, Fig. 7.

To clarify meaning and promote interchangeability.

14. *Batteries.*—Charging Receptacles for.—(a) That each electrically lighted car equipped with batteries shall be provided with two charging receptacles as shown on Sheet E, Figs. 11 and 12, so as to receive play shown on Sheet E, Fig. 13.

(b) These receptacles shall have swivel supports as shown on Sheet E, Fig. 10.

(c) These swivel supports shall be installed one on each side of the car as shown on Sheet D, Fig. 7, and Sheet F, Fig. 14.

(d) The outer annular contact shall be connected to the positive terminal of the battery as shown on Sheet D, Fig. 7, and Sheet E, Fig. 12.

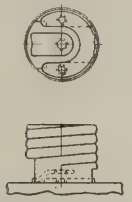
To eliminate obsolete types and bring the design up to date, giving such dimensions as are essential to interchangeability.

15. *Batteries.*—Fuses for, Etc.—(a) That each electrically lighted car equipped with battery box or boxes shall be provided with suitable metal fuse boxes, said boxes to be mounted close to the positive and negative terminals of each set of batteries as shown on Sheet D, Fig. 7, and Sheet F, Fig. 14.

(8) Do you approve of the above suggestion?

(b) These fuse boxes shall have mounted in them a block provided with fuse contacts having a capacity of 101 to 200 amperes, as shown on Sheet G, Figs. 16, 18, or preferably, Fig. 20.

TYPE OF CONTACT

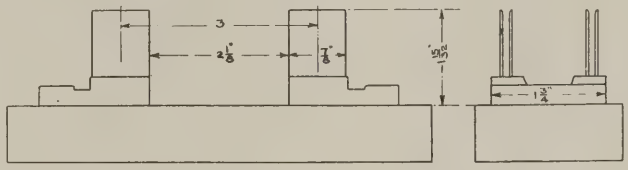


EDISON SCREW CONTACT
STANDARD N E CODE
CAPACITY - 0-30 AMPERES
250 VOLTS AND LESS

USED
ON SWITCHBOARD FOR
DISTRIBUTING CIRCUITS

FIG. 15.

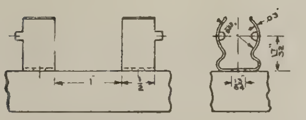
TYPE OF CONTACT



KNIFE BLADE CONTACT
STANDARD N E CODE
CAPACITY.— 110-150 AMPERES
250 VOLTS AND LESS

USED
IN BATTERY FUSE BOX WITH
TYPE D CARTRIDGE FUSE OR WITH LINK FUSE, FIG. 25 AND FUSE HOLDER, FIG 22

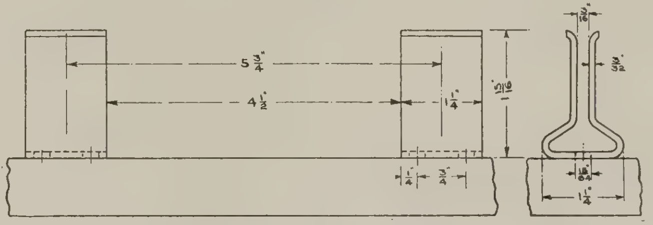
FIG. 16.



FERRULE CONTACT
STANDARD N.E CODE
CAPACITY - 0-30 AMPERES
250 VOLTS AND LESS

USED
ON AXLE GEN. REGULATOR PANEL FOR
FIELD CIRCUIT
VIBRATOR CIRCUIT

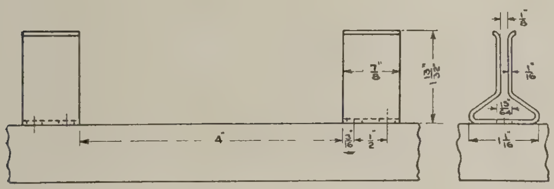
FIG. 17.



KNIFE BLADE CONTACT
STANDARD N E CODE
CAPACITY.— 101-200 AMPERES
250 VOLTS AND LESS

USED
IN BATTERY FUSE BOX WITH
KNIFE BLADE CARTRIDGE FUSE OR WITH LINK FUSE, FIG. 25 AND FUSE HOLDER, FIG. 26

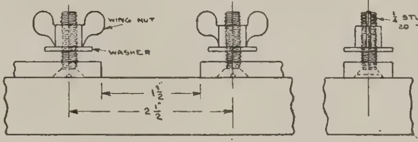
FIG. 18.



KNIFE BLADE CONTACT
STANDARD N. E. CODE
CAPACITY - 61-100 AMPERES
250 VOLTS AND LESS

USED
ON AXLE GEN REGULATOR PANEL FOR
AXLE GENERATOR ARMATURE CIRCUIT USING A FUSE HOLDER

FIG 19.



SCREW CONTACT
STANDARD N.E CODE
CAPACITY.— 101-200 AMPERES
250 VOLTS AND LESS

USED
ON SWITCHBOARD FOR
TRAIN LINE
BATTERY
MAIN LIGHTS WITH LINK FUSE FIG 24
IN BATTERY FUSE BOX WITH
LINK FUSE, FIG. 25

FIG. 20.

Figs. 15 to 20—Fuse Contacts

(9) Do you approve of the above suggestion?

(c) The fuse block shall be provided with contacts:

(1) To receive a link fuse as shown on Sheet H, Fig. 25, or

(2) To receive a standard N. E. Code 150 ampere cartridge fuse or

(3) A fuse holder to receive a link fuse as shown on Sheet H, Fig. 26 (designed to replace the N. E. Code cartridge fuse).

To clarify meaning, to provide for interchangeability and to cover all types of fuses and fuse blocks in general use.

(10) Do you approve of the above suggestions?

16. *Wiring.*—Terminals of.—(a) The terminal connections of the generating, regulating and controlling apparatus shall be marked for identification and polarity.

(b) The positive terminals shall be at the right, when facing the board (if terminals are arranged horizontally), and at the top (if arranged vertically).

Regrouping.

17. *Wiring.*—Train Lines and Connections.—(a) Cars operated in head-end system trains shall be equipped with three train line wires of No. 4/0 A. W. G.

(11) Do you approve of the above suggestion?

(b) Cars not operated in head-end system trains may be equipped with two train line wires of No. 2 A. W. G.

(12) Do you approve of the above suggestion?

(c) All cars equipped with train lines shall have the wires terminate in train line receptacles so designed that a standard train line connector as shown on Sheet I, Fig. 30 or Fig. 31, and located as shown on Sheet I, Fig. 29, may be used.

(13) Do you approve of the above suggestion?

(d) If only two wires are used they shall be connected to the outside terminals and the train line receptacle on each end of the car shall be stenciled: "NOT FOR USE ON HEAD-END SYSTEM."

(14) Do you approve of the above suggestion?

(e) Where three train line wires are used they shall be transposed as shown on Sheet I, Fig. 27.

(15) Do you approve of the above suggestion?

(f) Where two train line wires are used they shall be transposed as shown on Sheet I, Fig. 28.

(16) Do you approve of the above suggestion?

(g) Train line connections in each car shall be made across battery and generator circuit.

To clarify meaning.

(17) Do you approve of the above suggestion?

18. *Wiring.*—Generator Leads.—The electrical connections between the axle generator and permanent wiring on the car shall be made in such a manner that the leads can not be transposed.

To permit the use of a superior and less expensive construction of equal safety for use where such would seem to be desirable, as on body-suspended generators.

(18) Do you approve of the above suggestion?

19. *Wiring.*—Switchboards.—(a) That each electrically lighted car shall be provided with a switchboard upon which shall be mounted the necessary switches, fuse contacts and terminal connections.

(b) The switches and terminal connections shall be so arranged as to disconnect (when opened) and the fuses to protect the following parts, if same be used:

(1) Train line.
(2) Battery.
(3) Axle generator.
(4) Main light switch or fuses.

(5) Circuit for lamps, fans, etc.

(c) Each of the above switches or fuse contacts shall be plainly marked designating the part controlled or protected.

(d) The terminals for the axle generator at the generator regulator panel shall be arranged so that, when open, they shall disconnect the positive and negative armatures and one side of the field circuit.

Regrouping and to clear up ambiguity.

20. *Wiring.*—Fuses for, Etc.—(a) The switchboards or regulator panels of electrically lighted cars shall be provided with fuses for the protection of the parts given below:

(1) Train Line.—Contacts for use with open link fuses shall be provided, substantially as shown on Sheet G, Fig. 20, the stud or screw to be ¼ in. in diameter with twenty threads per inch set on 2½-in. centers.

(2) Battery.—Use of fuse optional. If fuse be used, the fuse and the fuse contacts shall be the same as for the train line.

(3) Main Light Switch.—Use of fuse optional. If fuse be used the fuse and fuse contacts shall be the same as for train line.

(4 Circuits.—For the distributing circuits to the lamps, fans, etc., the fuse receptacle shall be of the Edison screw-shell type as shown on Sheet G, Fig. 15.

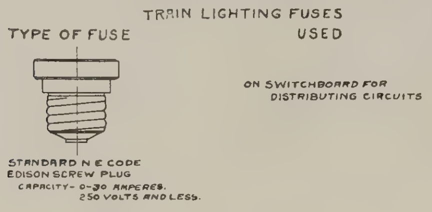


FIG.21.

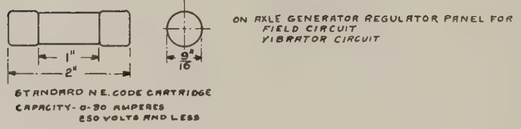


FIG.23.

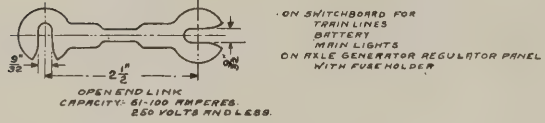


FIG.24.

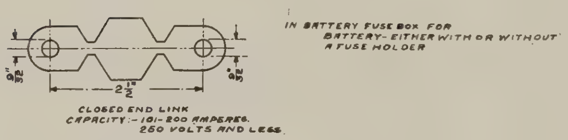


FIG.25.

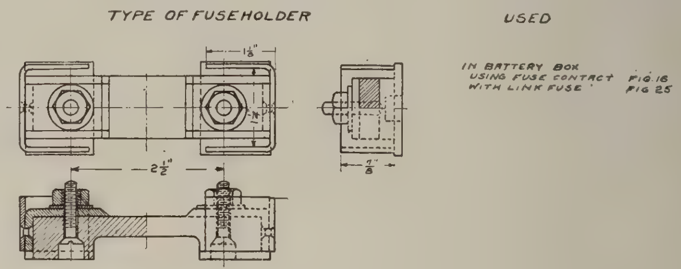


FIG.22.

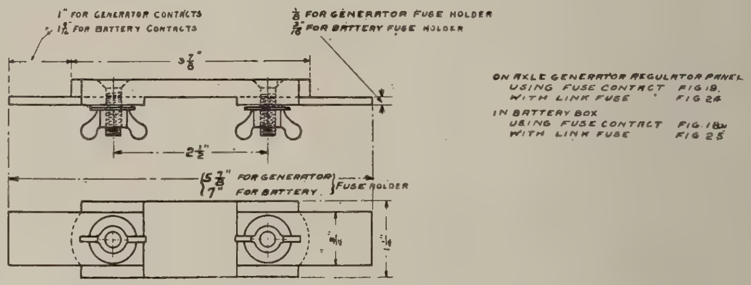

1" FOR GENERATOR CONTACTS
1 3/16" FOR BATTERY CONTACTS
1/8" FOR GENERATOR FUSE HOLDER
3/16" FOR BATTERY FUSE HOLDER
3⅞"
2½"
5⅞" FOR GENERATOR
7" FOR BATTERY.
FUSE HOLDER
ON AXLE GENERATOR REGULATOR PANEL
USING FUSE CONTACT FIG 19.
WITH LINK FUSE FIG 24
IN BATTERY BOX
USING FUSE CONTACT FIG. 18
WITH LINK FUSE FIG 25

FIG.26.

Figs. 21 to 26—Fuses and Fuse Holders

(5). Axle Generator.—The positive armature to have fuse contacts suitable for a 150-ampere knife blade N. E. Code fuse, with 4-in. clearance space between contacts as shown on Sheet G, Fig. 19.

(6) The use of a fuse in the field circuit is optional. If used, the contacts shall be suitable for a 0 to 30 ampere ferrule type, N. E. Code fuse with 1 in. clear space between contacts as shown on Sheet G, Fig. 17.

(b) All fuses on cars shall be used in the location and shall conform to the dimensions as shown on Sheets D., F., G. and H.

(c) The capacity of the fuses used in the above contacts shall be such as to protect the apparatus in question.

To cover all fuses in general use.

21. *Wiring.*—Installation of Conduit and Wire.—The following rules shall be used for car wiring:

(a) Conduit.—All conduits shall conform to the requirements of the National Electrical Code. It shall, wherever possiblé, be run on the interior of the car but not exposed to view. Ends of conduit shall be cut square and the interior reamed smooth, the contour of the material from the inner to the outer wall at the ends being approximately a quarter circle. Conduits shall not "butt" in couplings. Where threads on conduit are exposed they shall preferably be red or white leaded and painted. The

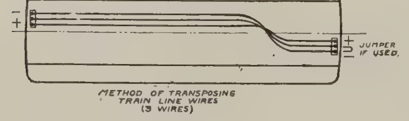


FIG. 27.

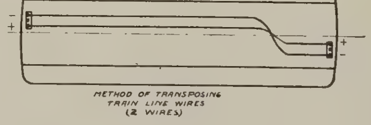


FIG.28.

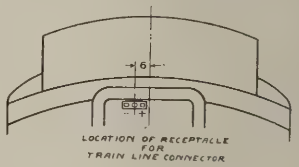


FIG. 29.

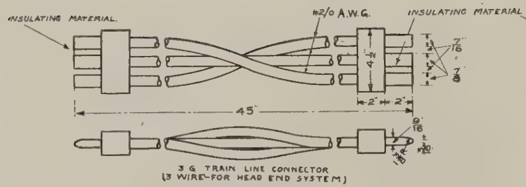


FIG.30.

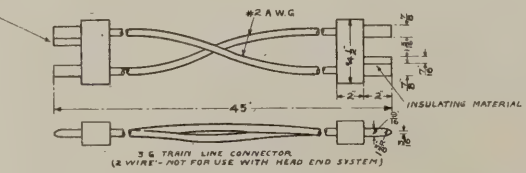
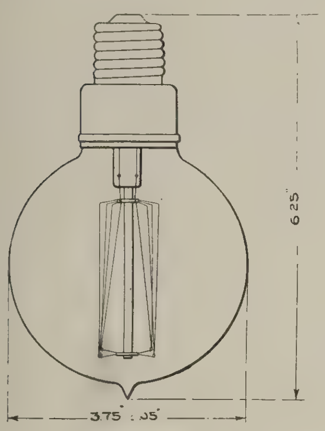


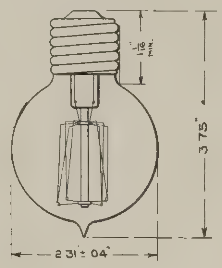
FIG.31.

Figs. 27 to 31—Train Lines, Connectors and Location of Train Line Receptacle conduit shall be of such a size and so arranged that the wires may be pulled in after the car is completed and pulled out for repairs without it being necessary to remove the interior finish of car. Conduit less than ⅜ in. shall not be used. Conduit and fittings shall be firmly and securely attached to the car body. The conduit system shall be so installed as to form a good, continuous electrical conductor and shall be grounded to the framework of the car. On steel or steel-underframe cars the supports of the conduit system will be considered as constituting an adequate ground. On wooden cars the conduit system shall be grounded by means of a copper wire of not less than No. 6 A. W. G. securely attached to the conduit and to some portion of the steel work of the car that has an electrical connection with the rail, so as to form a good electrical connection at the points of attachment. The connections of the ground wire shall be exposed to view and easily accessible.



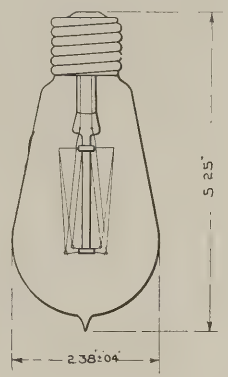
G 30 BULB

FIG.32



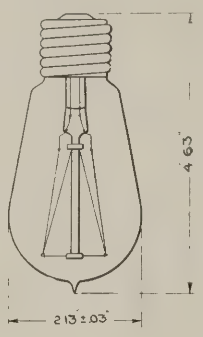
G 18½ BULB

FIG.33



S 19 BULB

FIG.34.



S 17 BULB

FIG.35.

Figs. 32 to 35—Train Lighting Lamps, Tungsten Filament with Bulb Dimensions

(b) Fuse, Junction Boxes, Etc.—Fuse, junction, outlet, connection and pull boxes exposed to the weather shall be of cast iron. The wall thickness at the bosses for the conduit shall be such as to ensure at least five threads of the conduit are engaged and that the interior of the boss be rounded off so as to provide the equivalent of an outlet bushing. "Knock-out" boxes or pressed or formed steel boxes may be used when not exposed to the weather, and, when used, locknuts shall be used on the conduit on both sides of the box wall and an outlet bushing on the end of the conduit. Pull boxes shall be installed where, on account of the length of run or number of bends, it would otherwise be difficult to pull in the wires. Fuse boxes for the main battery fuses shall be installed as close to the terminals of the battery, both positive and negative, as possible. All boxes shall be so installed as to render the covers of same readily accessible. The covers of boxes exposed to the weather shall be applied in such a manner as to render the box "weatherproof."

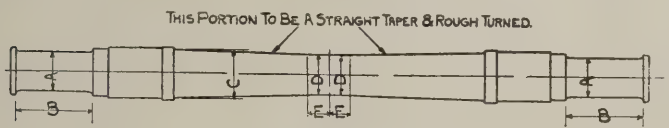


FIG.36.

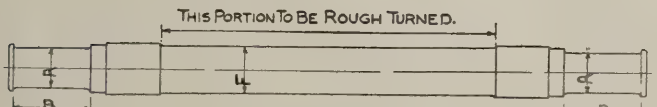


FIG.37.

JOURNAL	A	B	C	D	E	F
4¼"×8"	4¼"	8"	5 7/16"	4¾"	1½"	6 3/16"
5"×9"	5"	9"	6 3/16"	5⅜"	1½"	6 3/16"
5½"×10"	5½"	10"	6¾"	5⅞"	3"	6¾"

Figs. 36 and 37—Standard Car Axles Showing Portions to Be Turned for Application of Axle Pulleys

(c) Wire.—All wires shall be insulated with Grade "A" (30 per cent Para rubber) insulation if mineral base compound be used according to the specification of the Association of Railway Electrical Engineers, or equivalent, and shall be double braided, or if a wax base compound be used it shall be of a corresponding quality. No wire smaller than No. 14 A. W. G. shall be used, except for fixture work where No. 18 A. W. G. is permissible. All wires shall be run in metal conduit. No wire shall carry, under normal operating conditions, a current in excess of the values permitted by the National Electric Code for the size of wire in question. Train line wires on cars intended for service on head-end system shall be No. 4/0 A. W. G. Train line wires on cars not intended for service on head-end system shall be No. 2 A. W. G. All wires of No. 8 or larger shall be stranded. Train line connection between cars shall be as follows:

Head-End System.—No. 2/0 A. W. G., 833 strands or more, 5-64-in. insulation and one braid.

Not for Head-End System.—No. 2. A. W. G., 133 strands or more, 4-64 in. insulation and one weatherproof braid. The leads from the generator to the terminal connector on the car body shall be as follows:

Armature Leads.—No. 4 A. W. G., 61 strands, 4-64 in. insulation, one weatherproof braid.

Field Leads.—No. 8 A. W. G., 19 strands, 3-64 in. insulation, two weatherproof braids.

Joints and Splices.—The insulation shall be removed from the wire in such a manner that the wire shall not be cut, scored or nicked. All joints and splices shall be so made as to be both mechanically and electrically secure without the use of solder. All joints and splices shall be soldered, the soldering flux shall be free from acid. All wires joined or spliced shall be installed in such a manner that the joint or splices come in a junction box or fitting. Slack shall be left in wires at junction boxes and other outlets. Care should be taken that no sharp end of wire or solder is left to pierce the insulation and cause a ground. The joint or splice shall be covered with a rubber tape to the thickness of the original insulation, and this covered with friction tape to the overall diameter of the complete insulated wire.

The 1915 revised rules of the National Board of Fire Underwriters, as applying to car wiring, were drawn primarily to cover wiring of cars which are electrically propelled, and are therefore not applicable to electrically lighted cars in steam service. The rules proposed provide all the safeguards heretofore required by the Underwriters.

19. Do you approve of the above suggestions?

22. *Lamps.*—Standard lamps for car-lighting service shall be in accordance with the dimensions as shown on Sheet J, Figs. 32, 33, 34, 35.

Providing for the use of two additional styles of incandescent bulbs which are coming into general use.

20. Do you approve of the above suggestion?

23. *Axles.*—Dimensions, at Pulley Fit.—The dimensions of axles at the point of pulley fit shall be in accordance with dimensions shown on Sheet K, Figs. 36, 37.

No change in axles heretofore approved as Recommended Practice, but dimensions added to conform to M. C. B. Standard axles shown on Sheet M. C. B. 15 not now shown on Sheet M. C. B. 11 and which are essential to provide proper pulley fit.

24. Present paragraph 12, page 1025, of 1915 M. C. B. Proceedings, provides for emergency fuses as close as possible to the axle generator and prior to the leads from the same entering the conduit beneath the car floor. This feature was originally provided as a safeguard against fire hazard, but your committee feels that fire hazard from this cause does not exist to an extent sufficient to warrant the installation of such fuses, and such fuses have never been used except in a few isolated cases. It is therefore recommended that paragraph 12 of present Recommended Practices be eliminated.

21. Do you favor the elimination of paragraph 12?

Committee: D. J. CARTWRIGHT, Lehigh Valley, chairman; J. H. DAVIS, Baltimore & Ohio; E. W. JANSEN, Illinois Central; C. H. QUINN, Norfolk & Western; H. C. MELOY, New York Central; J. R. SLOAN, Pennsylvania; E. WANAMAKER, Chicago, Rock Island & Pacific; C. R. GILMAN, Chicago, Milwaukee & St. Paul; E. LUNN, Pullman Company.

Sub-Committee "A" on Standardization of Axle Generators*

C. H. QUINN, Norfolk & Western, chairman; J. R. SLOAN, Pennsylvania; H. C. MELOY, New York Central; D. J. CARTWRIGHT, Lehigh Valley.

Sub-Committee "B" on Head End Practice

Head end train lighting is as firmly established for through train service as ever, and for that service meets the requirements of lighting such trains in a very satisfactory manner. While the operation of the dynamo is often interfered with, the storage batteries tide over these interruptions and the lighting service is not materially affected. Its advantages are:

First—Brilliant uniform light in each car on the train. The uniformity of the lighting in each car in the train is of much more importance than one would imagine. The public traveler is very sensitive to this particular effect and contrasts between the lighting of different cars are quickly noticed and conveyed from one passenger to another. Of course, the type of fixture, the number and wattage of lamps affects this uniform result, but fixtures and wattage of lamps, also the number, can be definitely controlled, but the voltage of lighting equipment cannot always be controlled; therefore, lighting from one source or machine, other things being equal, obtains uniformity of the lighting flux in each car and is a distinct advantage in favor of the head end.

Second—A smaller investment is required for lighting a train and the operating expense per train is lower. However, this system is not applicable to a railroad operating a large number of first-class cars on short divisions where the service requires the constant breaking and making up of trains and diverting cars to side lines. Service of this kind can only be met by individual axle lighting equipment.

Steam Head End System

The general operation of the head end system is to light the train and charge the storage batteries en route. This is accomplished in two ways:

First—By connecting the battery across the two outside main train wires and dividing the 64 volt 32 cell battery in half, with a fixed resistance in one leg of each half, sufficient to hold the charging current down to normal while operating at normal lamp voltage (64). The chief objection is that in case the dynamo fails for any cause, the lamps burn at ½ voltage from the batteries until a switch is thrown at each battery on the train to restore the parallel connections to series.

Second—By connecting the 64 volt 32 cell batteries across the + and — dynamo main train wires, so that the whole battery is in parallel with the dynamo the same as in central station practice. In the dynamo baggage car a large resistance is placed across the two negative train wires and connected to a multiple point switch. By opening the loop in rear of train and closing it at the dynamo switchboard this resistance is brought into series with the entire lamp load of the train and the voltage of the lamps is thereby controlled. The dynamo voltage may then be raised to any point required to put a full charge into the battery. The entire operation is controlled by the baggageman in the dynamo car and by the meters on the switchboard he can judge just what is going on in his train and about what amount of current each battery is taking. This arrangement is being used by the Chicago, Burlington & Quincy, the Northern Pacific and the Chicago, Milwaukee & St. Paul.

Axle Head End System

The Northern Pacific has for the past two years been operating a head end 25 kw. axle driven dynamo on one of its trains with very satisfactory results. The committee's report at our 1914 convention in Chicago fully described the operation of this device and pointed out the saving in operating expenses over the standard steam driven dynamo for head end train lighting. I have a short, up-to-date report from the Northern Pacific on this axle system, as follows:

March 17, 1916—The original car has made 140,000 miles without a lighting failure. The original driving chains made 120,000 miles before it was necessary to renew the pins. The chains have been repinned and are practically as good as new, and we expect to obtain approximately the same mileage from them.

Two new equipments were put in service on steel cars 1418 and 1419 on June 8, 1915. These cars are operating in trains Nos. 65 and 66, between St. Paul and Duluth. The service is local. To date each equipment has made 44,000 miles without a light failure.

The enginemen on this division (the Lake Superior) estimate that a saving of one ton of coal per night over the head end turbine system is made. This is equivalent to approximately 200 lb. of coal per hour of lighting. The same enginemen state they can notice no difference whatever in the pulling of the train.

Among other advantages of the system is that the steam leakage between tender and dynamo car is reduced to a minimum, inasmuch as the pressure carried is reduced to an amount just sufficient to supply the necessary steam heat. Steam leakage between tender and dynamo car and the exhaust from the turbine while standing in stations are frequently a great hindrance to enginemen in making proper location stops and in observation of signals from train crews. This is particularly troublesome in cold weather. The service rendered by the new equipments has been satisfactory both mechanically and in efficiency of operation.

We are at the present time installing an additional equipment on the Minnesota & International, a subsidiary line of this company. This equipment consists of a 16½ kw., 80 volt, six pole, commutating pole, flat compound wound direct current generator equipped with roller bearings. The generator is driven with a 5-in. Morse silent chain from a roller bearing countershaft. The countershaft is in turn driven with a 5-in. Morse chain from the forward axle of the forward truck. All pinions are of gray iron without flanges.

The control apparatus consists of one generator panel, one lamp regulator panel and one lamp regulator multiplier panel. The generator control panel is so designed that it will limit the total generator current to either 100, 125, 150, 175 or 200 amperes, and limit the generator voltage to 78 volts cold and 83 volts hot, and also so designed that the automatic switch will cut in when generator voltage reaches 66 volts cold and 68 volts hot, and drop out when there is a reversed current of 10 amperes flowing through its coil. The lamp regulator is of sufficient capacity to handle an entire train and when hot to maintain lamp voltage at 66 volts with a maximum gradual variation of 1½ volts each side of normal, with a current range of from 20 to 125 amperes.

The difference between the new equipment for the Minnesota & International and the first three equipments is in the design of the suspension. In the new design the generator and jack shaft are fastened to the same castings making them always in line, which, as you will readily see, is very essential. In addition, the center line of the jack shaft was raised slightly so that it lies in the same horizontal plane as the car wheel axle, producing a minimum change in chain tension, due to vertical movements of the car axle. The design of suspension under this car is now such that it can be applied to any standard truck. The suspension is so arranged that it is all above the truck frame, which very materially facilitates the handling of wheels in and out of trucks at repair points.

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*This committee will make a verbal report.

We expect to put the Minnesota & International service into effect in about two weeks.

Headlight Turbine Head End System

The latest scheme in head end lighting is to use the locomotive electrict headlight turbo-generator. Locomotives are required by law to carry an electric-lighted head lamp, and it is of such importance that it is surrounded by every safeguard that can be devised to keep it in operation. It, therefore, became a very reliable source for lighting lamps in cars, within the capacity of the headlight generator, on short outlying divisions, where the expense of the regular electric train lighting devices are not warranted. This system is well described by L. S. Billan, asst. electrical engineer of the Baltimore & Ohio, as follows:

"Data pertaining to electric lighting of Staten Island trains and notes on head end system of train lighting with headlight generating equipment.

"There are certain classes of passenger train service where it is desirable to use a system of electric lighting that requires little or no expert attention and that is considerably lower in first and operating cost than the systems in general use. The development of turbo-generator equipment for locomotive headlight service to a point where it is reliable and possesses close voltage regulation has made possible its use for train lighting purposes, although to a very limited extent. The small capacity of generator sets and the fact that it is impracticable to use storage batteries with them confines the use of this head end system of electric lighting to trains of short length and which can be operated intact, including the locomotives, throughout their entire runs. As common to all forms of head end system where no secondary lighting is provided the cars can be operated only in trains properly equipped.

"The operating conditions of passenger train service on the Staten Island Railway and the Staten Island Rapid Transit Railway, subsidiary companies of the Baltimore & Ohio system, are admirably adapted for the use of this system. With a view to improving the lighting of these cars which have heretofore been using oil lamps, electric lighting is now being installed on the entire passenger equipment. These railroads operate on Staten Island, New York, the passenger service being exclusively suburban and local in character, while the equipment is smaller size than standard steam railroad passenger cars and cannot be operated with them.

"The 110 volt, two-wire train line, head end system has been installed, current being supplied from special turbine generator headlight equipments mounted on the locomotives, no batteries being employed. The 110 volt system was adopted to permit lighting cars at the terminal points from the station service if it were ever found desirable to do so and to permit using small size train line wires. On account of these cars being unable to operate in interchange with standard railroad equipment, the objection to adopting the special voltage did not hold good in this case.

"The turbine generator equipments are of special design of 2,500 watt capacity and generators are wound for 110 volts. There are twenty-four equipments being installed, twelve being furnished by the Schroeder Headlight Company and twelve by the Plye-National Electric Company. This capacity was required on account of lighting load of train, the normal maximum length being six cars, occasionally reaching eight cars. The cars are equipped with four or five lighting fixtures, depending upon the length of the car, at approximately three-seat spacings. Standard 60 watt 110 volt tungsten lamps with Holophane velvet finish reflectors are employed. The fixtures are of the pendant type, designed primarily for street car service, and are mounted from condulet fittings, the conduit being located on the ceiling of the car. There is but a single lighting circuit per car, thus eliminating necessity for switchboard panel, a standard condulet type of box with switch and cut-out being used. Wiring diagrams, bills of wiring material, conduit diagrams, photographs, etc., of this system as well as of a similar system installed on the Chicago & North Western were given in an article appearing in the June, 1916, issue of the *Railway Electrical Engineer*.

"A special car coupler for the electric circuits has been used, being located below the platform. These couplers were manufactured by the Consolidated Car Heating Company, having been designed originally for use on certain elevated lines in New York for carrying the electric lighting circuits through the train. The jumpers are of single conductor type one side of the circuit being run on one side of the car and one on the other. The purpose of using a coupler of this general design is to secure a construction in which one end of jumper is permanently attached to the car wiring. Installation cost for car wiring, conduit and fixtures is approximately $75.00 per car and $210.00 per locomotive, including the turbine equipment, wiring, etc.

"Some tests made showed a very satisfactory voltage regulation, the maximum variation not exceeding 5 volts within the normal load of turbine and working limits of the steam pressure. The same general system of head end lighting is also being installed on two or three trains in local and branch line service on the Baltimore & Ohio system. In this case the 30 volt system, with the standard M. C. B. train line jumper connections between cars (Gibb connectors), has been adopted to conform to the standard train lighting practice. This permits cars equipped with other systems of electric lighting but provided with a standard train line operating in these trains without interfering with the head end system for the remaining cars and also in case the branch line cars should occasionally get into main line service they can be lighted by train line from an axle generator car."

The Chicago & North Western Ry. is also using locomotive head lamp equipments for lighting small trains.

The general standard scheme of wire on the cars is used. However, the details differ as follows: They are using the standard headlight turbine at 30 volts and the trains consist of three or four cars, with the lighting load distributed as follows: 270 watts on locomotive, 120 watts in baggage car, 230 watts in coach, making a total of 850 watts for a three car train and 1,080 watts for a four car train. While this service has been in use but a short time, the results lead the Chicago & Northwestern to feel it fills a very desirable place in electric train lightning.

Ampere hour storage battery control in head end lighted cars is being studied. While this apparatus is in general use on axle-driven devices, its use on head end battery lighted cars has not been satisfactorily worked out. We have applied an ampere hour control to one of our head end cars, and it has been in use so short a time I cannot give a report. It seems reasonably certain that it will work and fill an important place in the control of storage battery charging on head end lighted cars.

Sub-committee—C. R. GILMAN, Chicago, Milwaukee & St. Paul, chairman.

Illumination

Your committee this year has continued the work from last year and investigated such other subjects as were recommended by the executive committee. These cover (a) the results of an extensive study of the problem of properly illuminating railroad yards, (b) changes in the rating of train lighting lamps and the determination upon standard sizes of type C or gas filled lamps for train lighting service, (c) progress report on the revision of the association's incandescent lamp specifications, and (d) in line with the practice established last year a brief résumé of the more important developments in the incandescent lamp field.

Sub-Committee "A" on Illumination of Railroad Yards

The importance of securing more efficient and rapid operation of railroad yards at night time has long been recognized, but relatively little study has been given to the subject of securing adequate artificial illumination that will permit operation approaching daylight conditions. Also the increased damage to rolling stock and freight occurring in yards at night time should be materially reduced by the providing of ample and proper illumination. During the past two years your committee has therefore devoted considerable time and effort to the investigation of this subject, the results of which are embodied in the following:

Methods of Mounting Lighting Units

There are three practical methods of supporting lighting units. These are: 1. Towers. 2. Poles. 3. Catenary construction. Towers may be built to any height desired, and become cheaper

per foot of height as the height is increased (within limits). Tower construction is, in the majority of cases, not economical on account of the high first cost and the possibility of future changes or removal of the yards, which would make the towers useless. Catenary construction is excellent in allowing proper location of units, but is expensive and subject to rapid deterioration. For wide spacing of units, towers or poles are the most economical—poles being preferable in the majority of cases. For close spacing of units, catenary construction will be found the cheapest and most satisfactory. The usual space between poles for distribution lines is about 100 ft. The most economical installation will use these poles for supporting the lighting units. This would allow lighting units to be placed either 100 ft. or 200 ft. apart and approximately 35 ft. in the air (35 feet being the most practical mounting height on wooden poles).

The Photometric Curve

Intensity of light, or candle-power, is measured by an instrument known as the photometer. This compares the intensity being measured, with the known intensity of a standard lamp and evaluates the former in terms of the latter. The photometric curve is a curve showing these measured candle-power values of a light source, in all directions in a given plane. The photometric curve is, then, the graphical representation of the suitability of a lighting unit for certain spacings and mounting heights, as far as the proper distribution of light from these units is concerned. Your committee has decided to use the photometric curve as the proper basis upon which to make its recommendations, rather than to specify the use of any particular lighting units.

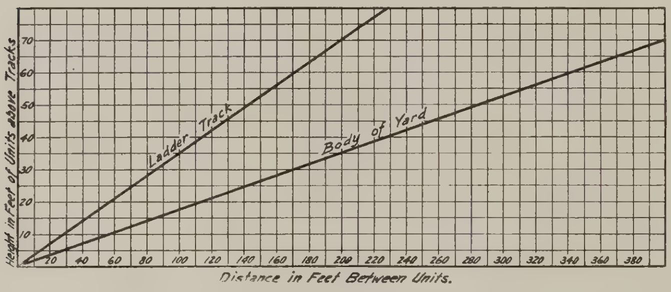

Fig. 1—Spacing Distance Between Units for Various Heights of Lighting Units Above Tracks

Types of Yards

The four general classes of yards whose efficiency can be more or less increased by proper artificial lighting are:

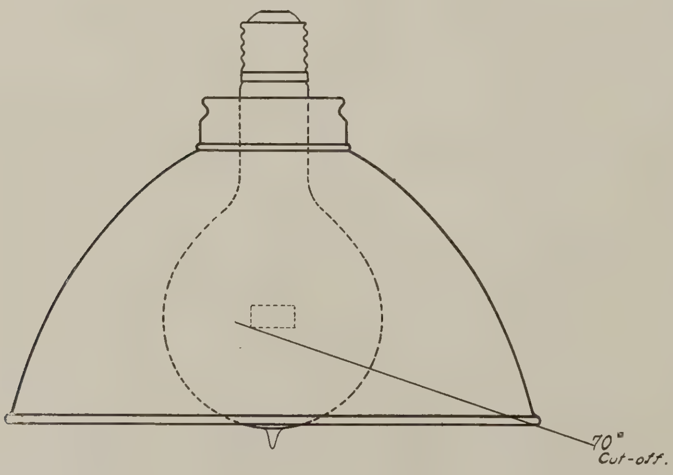

Fig. 2—Type of Reflector for Lighting Approach to Apex of Hump

1. Classification yards.
2. Reloading yards—yards in which freight is unloaded to the ground and transferred to other cars or boats.
3. Repair yards.
4. Storage yards.

Of these four types, the Classification Yard is by far the most important. For this reason your committee has devoted most of its time to the study of this one type of yard and will give only general suggestions in this report as to the methods of lighting the other three types.

Recommendations for Classification Yard Lighting

When considering the question of lighting a classification yard, it should be divided into the following sections:

1. Approach to apex of hump.

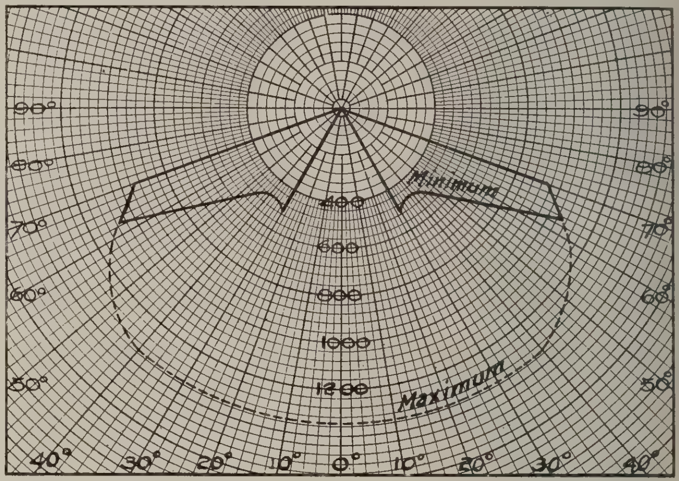

Fig. 3—Maximum and Minimum Distribution Curve for Reflector for Lighting Units Placed at Approach to Apex of Hump, Candle Power Values for 35 Ft. Mounting Height.

2. Apex of hump. (a) With scales. (b) Without scales.
3. Ladder track.
4. Body of yard.

Approach to Apex of Hump

1. Units should be spaced as shown in Fig. 1.
2. Units should be placed on side of track from which car cutters operate.
3. Units should be placed 1/3 their mounting height from side of track.
4. A reflector should be used that covers the lamp, keeps light out of the eyes of trainmen and does not interfere with signals. (Fig. 2 shows such a unit.)
5. A unit should be used giving a distribution of light coming within the limits shown by Fig. 3.
6. The candle-power values shown in Fig. 3 should be multiplied by the factor shown in Fig. 4, when mounting the height of units is other than 35 feet.

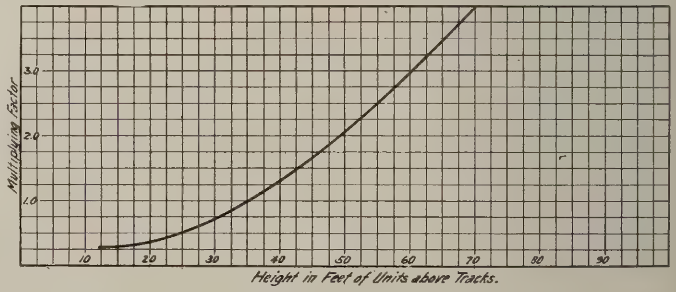

Fig. 4—Multiplying Factors for Candle Power Values to Be Used with Mounting Heights of Other Than 35 Ft.

Apex of Hump

1. With scales—lighting should be as shown in Fig. 5.
2. Without scales—one unit giving a distribution of light as shown by Fig. 3, should be mounted on each side of the tracks, 30 feet above the tracks and 16 feet out from side of tracks.

Ladder Tracks

1. Units should not exceed spacings shown in Fig. 1. (It is preferable to us 3/4 values for distance between units.)
2. Units should be placed as close to switches as possible.
3. Every switch should have a unit not more than 40 feet distant from it.

4. A unit should be used giving a distribution similar to the maximum curve shown by Fig. 3.

5. The candle-power values shown by maximum curve in Fig. 3 should be multiplied by the factor in Fig. 4, when mounting height of units is other than 35 feet.

Body of Yard

1. Units in a row should be spaced as shown in Fig. 1.

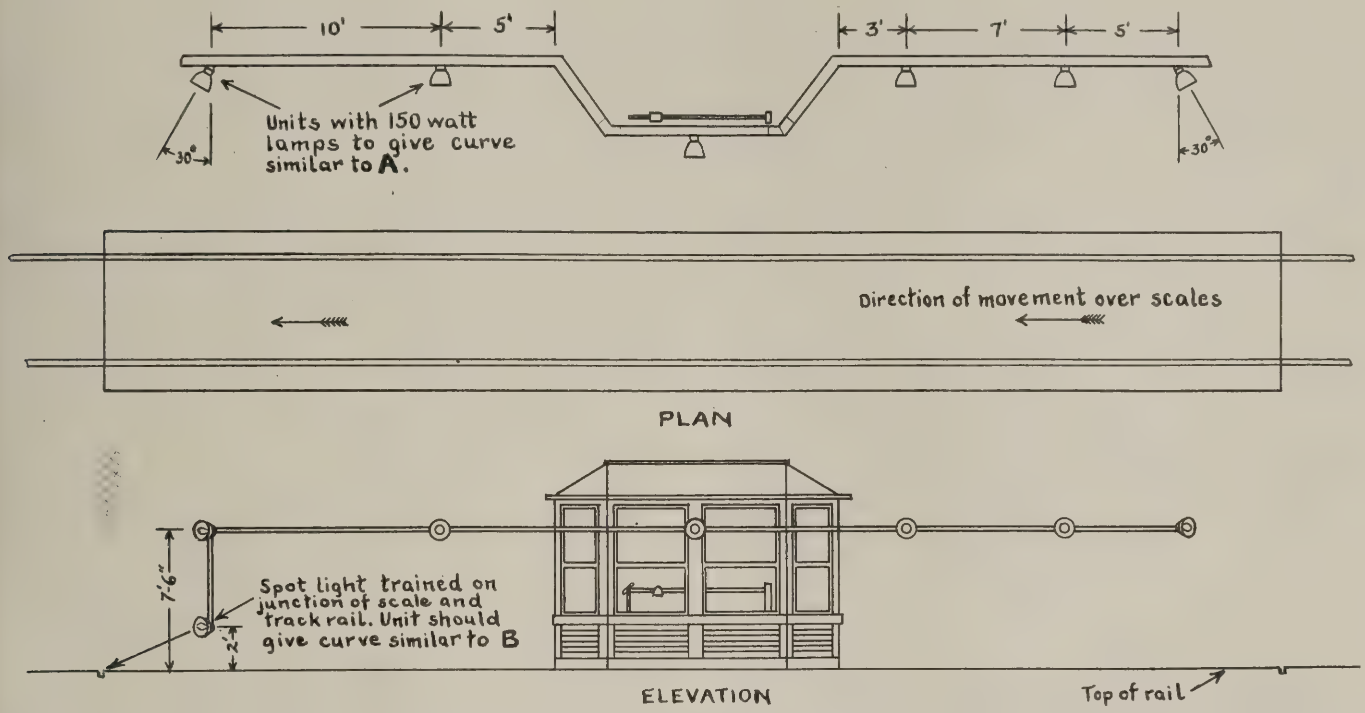
10'
5'
3'
7'
5'
Units with 150 watt lamps to give curve similar to A.
30°
30°
Direction of movement over scales
PLAN
7'-6"
2'
Spot light trained on junction of scale and track rail. Unit should give curve similar to B
ELEVATION
Top of rail

Fig. 5—Arrangement of Lighting Units for Track Scales Lighting. Distribution Curves for the Lighting Units Used Are Shown in Fig. 5A.

2. Rows of units should not exceed spacings shown in Fig. 1. (It is preferable to use 3/4 values for distance between rows.)

3. Units in adjacent rows should be staggered.

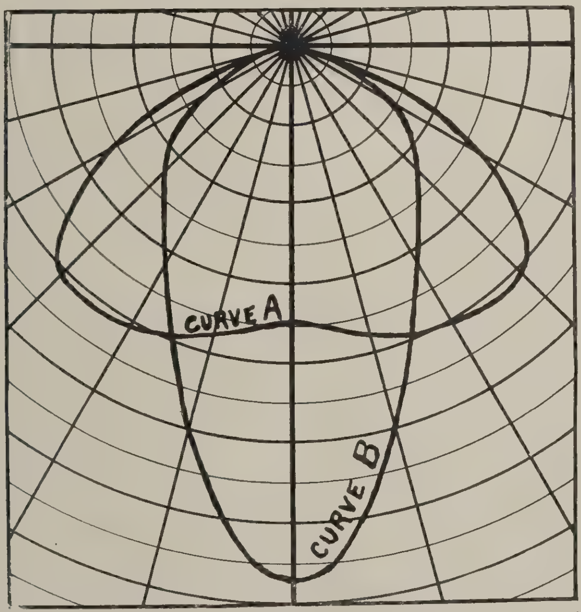

Fig. 5A—Distribution Curves for Track Scale Lighting Units Arranged as Shown in Fig. 5

4. A unit should be used giving a distribution of light coming within the limits shown by Fig. 6.

5. The candle-power values shown in Fig. 6 should be multiplied by the factor shown in Fig. 4, when the mounting height of units is other than 35 feet.

Typical Lay-Out of Yard

Figure 7 shows a typical yard lay-out, with lighting units located in accordance with the specification outlined above.

Reloading Yards

Reloading yards have no particular standard characteristics and are laid out in so many different ways that it is impossible to make standard recommendations for the illumination of this type of yard.

There are usually fairly large open spaces between tracks, in which most of the work is done. These spaces should have a moderate, uniform horizontal illumination and glare should be eliminated as much as possible. Probably a unit giving a distribution similar to the maximum curve in Fig. 3 is the best for this work. The distance between units should be about 2½ times their mounting height.

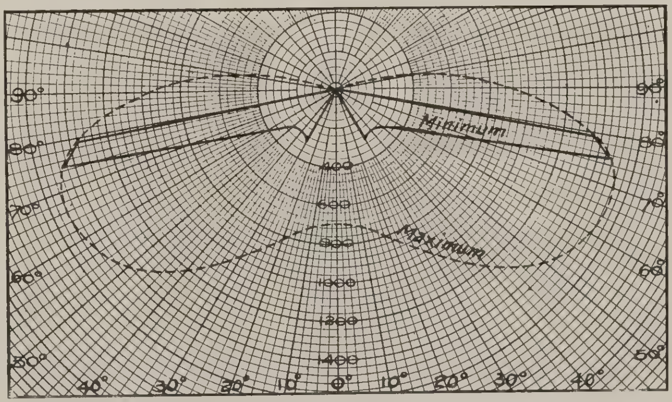

Fig. 6—Maximum and Minimum Distribution Curve for Lighting Units Placed in the Body of the Yard, Candle Power Values for 35 Ft. Mounting Height.

Repair Yards

A repair yard consists of a number of tracks spaced close together. Each of the cars on these tracks should be evenly lighted on the roof and sides and as much light should be thrown under the cars as is possible. This means that there should be a row of lighting units between each pair of tracks. The units should be placed about 16 feet above the ground with a distance between units of approximately 30 feet. The best unit for this service is a 100-watt or 200-watt tungsten Type C lamp with a porcelain enameled shallow dome reflector which covers the lamp filament to about 10 degrees below the horizontal. For supporting these lighting units, catenary suspension will be found satisfactory.

Storage Yards

A storage yard should require very little lighting. About all that is needed is general illumination sufficient to permit passage among the cars without danger and to discourage unlawfulness.

A system of lighting similar to that recommended for the body of a classification yard is satisfactory, although a lower intensity of illumination may be permitted. Another method is to use search lights, or projectors at one or both ends of the yard, which direct beams of light down between the rows of cars. On account of objectionable glare effect from such arrangement of lights it is not as satisfactory as the former method recommended.

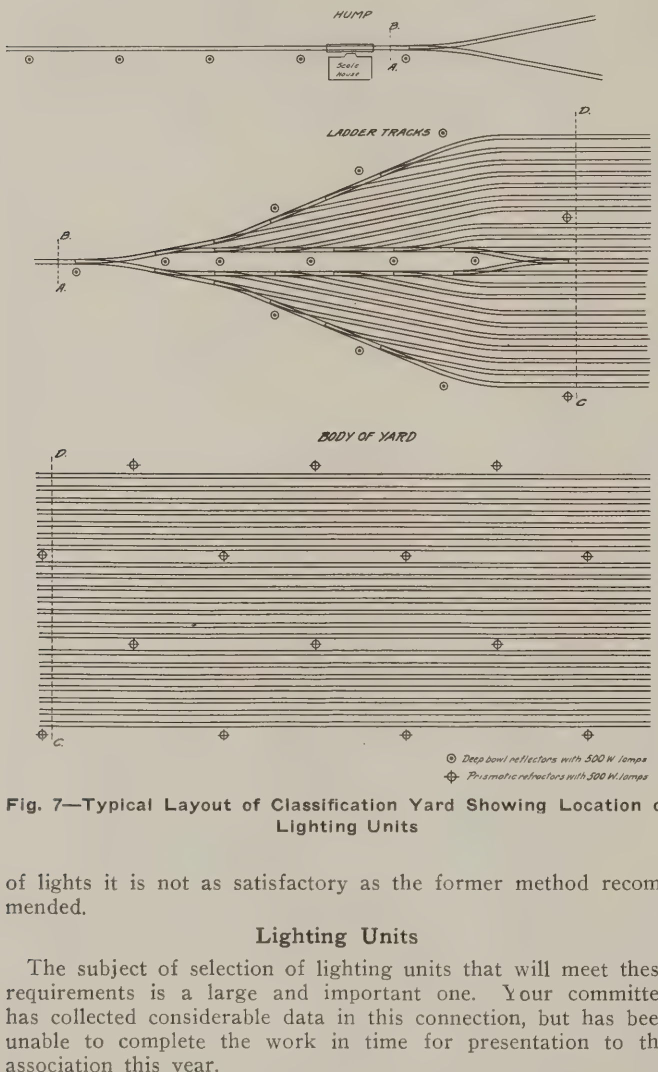
HUMP
B.
Scale house
A.
D.
LADDER TRACKS
B.
A.
C
BODY OF YARD
D.
C
Deep bowl reflectors with 500 W. lamps
Prismatic refractors with 500 W. lamps

Fig. 7—Typical Layout of Classification Yard Showing Location of Lighting Units

Lighting Units

The subject of selection of lighting units that will meet these requirements is a large and important one. Your committee has collected considerable data in this connection, but has been unable to complete the work in time for presentation to the association this year.

Sub-Committee “B” on Rating of Train Lighting Lamps

A preliminary report was made at the Atlantic City convention last June concerning the rating of train lighting lamps, and it was ordered that the report then made be submitted to letter ballot. The report has been revised for this purpose as follows:

The introduction of the gas filled lamp brings with it a change in the method of rating. This type of lamp should not be rated in terms of mean horizontal candle-power as this value varies greatly in lamps of the same size. It was at first intended to use the mean spherical candle-power as the basis for rating. There is serious objection to this, however, as the mean spherical value of a given lamp is usually less than its mean horizontal value, consequently purchasers are very likely to assume that the candle-power of the lamp has been reduced. It appears advisable, therefore, to recommend that this type of lamp be rated in total lumens, the total lumens being the equivalent of the spherical candle-power multiplied by 12.57. The lumen values shall be used for inspection and test purposes only, while the lamps shall continue to be sold under and known by their wattage names.

So far as the train lighting schedules are concerned, the gas filled lamp can probably be furnished eventually in sizes from 15 watts upward for the 30-34 volt range, and from 25 watts upward for the 60-65 volt range. This leaves one lamp in the 30-34 volt range and three in the 60-65 volt range of the vacuum type which are now rated in mean horizontal candle-power, but which can be rated in total lumens equally well. It is recommended that these four lamps also be rated in total lumens so as to place all of the lamps in train lighting service on the same basis of rating.

In preparing new schedules for train lighting lamps in which inspection limits, etc., are now based upon total lumens, it will be necessary to make slight changes in the sizes of some of the lamps now used. The following tabulation gives the lumen values for the lamps now regularly manufactured, also the proposed total lumens in accordance with the changes above outlined.

Nominal Size of Lamp in Watts	Present Total Lumens	Proposed Total Lumens
10	85	85
15	130	125
20	180	175
25	220	250
40	390	500
75	815	*
80	†	1,000
120	‡	1,500

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*This lamp to be abandoned.

†Substitute for 75 watt lamp.

‡New lamp.

Note: The 500, 1,000 and 1,500 lumen lamps will be available only in the gas filled type.

There will be slight differences of efficiency in these lamps owing to the two voltage ranges used in train lighting service. The two following schedules show the approximate sizes of train lighting lamps in both the 30-34 and the 60-34 volt ranges, also the proposed lumen value, bulb designation, etc. It is expected that the progress of the art during the next few years will permit the lamps marked thus (*) being made in the gas filled type.

30-34 VOLT RANGES.

Nominal Sizes in Watts	Total Lumens	Lumens per Watt	Bulb Designation	Length Over all Inches
10	85	....	S-17	4⅝
*15	125	....		
*20	175	....		
*25	250	....		
*40	500	13.2	PS-20	5 to 5½
*80	1,000	14.80	PS-22	6⅛
*120	1,500	15.7	PS-25	7⅛

60-65 VOLT RANGES.

Nominal Sizes in Watts	Total Lumens	Lumens per Watt	Bulb Designation	Length Over all Inches
10	85	....	S-17	4⅝
15	125	....	S-17	4⅝
20	175	....	S-17	4⅝
*25	250	....	....	....
*40	500	10.90	PS-20	5 to 5½
*80	1,000	13.20	PS-22	6⅛
*120	1,500	13.95	PS-25	7⅛

There is practically no demand for the present 75-watt lamp, and the demand for the proposed 80-watt lamp will also probably be very limited. For this reason it is proposed to drop these lamps from the published schedules with the understanding that the manufacturers will hold themselves ready at all times to furnish 80-watt gas-filled lamp in case any railroad desires to use it. If the demand for it increases it can be placed in the schedule at any time.

Your committee feels that the range of the sizes in the proposed schedule is sufficient to meet all the train lighting requirements and would recommend that as railroads may adopt the use of gas filled lamps for this purpose they confine their requirements to the proposed standard sizes and types as for obvious reasons it is undesirable to develop special sizes or types of lamps to meet limited demand.

Revision of A. R. E. E. Incandescent Lamp Specifications

The development of the gas filled incandescent lamp has demonstrated the necessity for adoption of some other method of lamp rating than the mean horizontal candle-power basis. The inaccuracy of using the mean horizontal candle-power as a measure of the total illuminating value is so great for this type of lamp that the practice has had to be abandoned and as a consequence the mean spherical candle-power basis has now been substituted by the lamp manufacturers for the gas filled and also vacuum types of lamp. As they will involve rather extensive changes in the present standard specifications your committee deemed it inadvisable to present a revised issue until developments reached the point where this feature can be taken into consideration. In revising the existing lamp specifications of the association your committee desires to go on record as favoring the adoption of the following:

1. The form of specification shall comprise two parts; one covering the general text of the specifications which is likely to require but infrequent revision and may therefore be prepared in printed or other permanent form; the other covering the various lamp schedules which are subject to comparatively frequent changes and should therefore be prepared in loose leaf form supplementary to the body of specifications that will permit the ready revision of any or all of the schedules without necessity for reissuing the entire specification.

2. The lumen as the unit of light flux shall be substituted for candle-power for lamp rating purposes. It should be understood that this does not imply that the nominal rating or name (watts or candle-power) by which the lamps are designated should necessarily be changed at the same time.

The lumen is the unit for measurement of quantity of light and has been approved by scientific and engineering societies and by leading engineering opinion. The lumens value for any lamp is readily obtained by multiplying the mean spherical candlepower by 12.57 (4π).

Incidental to rating lamps in the terms of this unit the lamp efficiency will be expressed in lumens per watt instead of watts per candle. This latter term as a measure of lamp efficiency is a misnomer as it actually expresses the specific consumption of the lamp and therefore an increase in efficiency of the lamp will show an increase in the lumens per watt which is a more logical and proper method of expressing efficiency than by a method employing reciprocal values.

Present developments would indicate that it will be practicable to revise the specifications during the coming year to include these features and that at the next convention a reissue of the present specifications can be presented to the association.

Development in Incandescent Lamp Field

Development in incandescent lamps during the past year has been largely in the nature of refinements in manufacture resulting in improvement in quality, better uniformity of product and in some lamp sizes higher efficiency. New lamps that have been placed on the market since last year's report are:

250 watt gas filled, G-30 bulb, 105-125 volt flood-lighting lamp.

100 watt gas filled, G-25, 105-125 volt stereopticon lamp, replacing vacuum, G-30 bulb lamp of same character.

75 watt gas filled, PS-22 bulb, 105-125 volt lamp for multiple burning service.

50 watt vacuum, S-19 bulb, 105-125 volt lamp for multiple burning service.

Attention is called also to the serious problems the lamp manufacturers have had to meet due to the unsettled conditions brought about by the war. The importation of raw material used in the manufacture of incandescent lamps has been greatly curtailed and at the same time much new business has come to America which formerly went to Europe. This has placed the American manufacturers in an embarrassing position. It has been necessary for them to develop quickly new sources of raw material and to increase greatly their production. Labor has been scarce and difficult to secure. By the development of new automatic and semi-automatic machinery for use in various processes of lamp manufacture it has been possible to meet the situation successfully to a large extent and at the same time furnish the finished product at no increase in price, in face of the marked rise in cost of raw material and labor. The use of such machinery will also tend to increase materially the uniformity of the lamp product.

Recommendations

The activity of this committee during the coming year should be directed primarily towards the revision of specifications for the purchase of incandescent lamps along the lines outlined, the standardization of voltages for all classes of lamps and a thorough investigation of incandescent lamps for locomotive headlight purposes.

Committee: L. S. Billau, Baltimore & Ohio, chairman; Joseph A. Andreucetti, Chicago & North Western; J. E. Gardner, Chicago, Burlington & Quincy; H. C. Meloy, New York Central; J. L. Minick, Pennsylvania; G. O. Moores, Edison Lamp Works of General Electric Company; L. C. Por-Baltimore & Ohio; J. R. Sloan, Pennsylvania; C. W. Bender, National Lamp Works; L. C. Doane, Ivanhoe-Regent Works; W. H. Rolison, Westinghouse Lamp Company; H. Schroeder. ter, Edison Lamp Works of General Electric Company.

Wireless Telephone and Telegraph as Applied to Moving Trains*

Dr. F. H. Millener, Union Pacific, chairman; J. H. Wickman, Illinois Central; D. J. Cartwright, Lehigh Valley.

Auditing Committee*

H. G. Myers, Atchison, Topeka & Santa Fe, chairman; R. Pachaly, Chicago, Rock Island & Pacific; J. G. Eberler, Chicago, Rock Island & Pacific.

Illumination and Efficiency

Careful attention should be given the proper lighting of the workshop and factory or of any industrial establishment. The intimate relation between good illumination and the efficiency, safety, and bodily welfare of the employee should be considered and steps taken to see that good illumination is afforded all workers. For years many have been working in the dark, yet none would venture to say that a workman could work to his full capacity unless his work were adequately and properly illuminated. The most enthusiastic supporters of proper lighting for shops are those who have taken the steps to insure it and have seen the benefits thus derived. Increased efficiency in mills, varying from 2 to 10 per cent has been reported as a result of improved lighting conditions. The industrial commission of one state reports that in one steel plant an efficient lighting system was installed and the output at night was increased 10 per cent. To determine if this increase was due to the illumination, the old system was tried for a time and the output fell 10 per cent. The improved lighting system was used again and the output rose to that attained before. The ill effects of bad lighting, such as impairment of eyesight, the depressing effect on the worker, and his resulting attitude toward his work and his employer, should also be considered.—*Technical Paper* 102, *Department of the Interior, on Health Conservation at Steel Mills.*

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*This committee will make a verbal report.

A. B. C. Car Lighting Course

Lesson No. 55

The Stone-Franklin System

In the last three lessons we have covered the theoretical operation and the details of construction of the Stone-Franklin Car Lighting System, also the maintenance of the generator and suspension. This lesson will be devoted to the switchboard equipment.

While the auxiliary apparatus for the predecessor of the Stone-Franklin equipment—the Stone equipment—was designed entirely for underframe application, the modern Stone-Franklin equipment has been so remodeled and designed to conform with the standard American practice, that the necessary automatic switches are mounted on panels as shown in Fig. 1. The complete panel is located inside the car in the switchboard locker so that the wiring to the underframe is greatly simplified and the switch apparatus is more accessible and more readily maintained; in other words, the Franklin Railway Supply Company has adopted a method of application which is considered best car lighting practice in the United States.

The Switchboard Panels

The modern Stone-Franklin equipment is now operating with ampere hour meter control in order to still further protect the batteries from harmful overcharging, and a special panel has been designed for this purpose, known as type L. The type D panel contains the automatic cut-in and out switch, the battery change-over switch, the generator field and main fuses and the lamp resistances. The main light switchboard on the top of the panel consists of a 4, 6 or 10 circuit board; fitted with main light and train line switch, and plug fuses and subsidiary switches for the various lamp circuits. All the wiring is of busbar construction and is readily accessible.

Single Battery Equipment

For non-passenger carrying cars the Franklin Company is manufacturing a single battery equipment with which the standard T-35 generator is used. The auxiliary apparatus is mounted on a panel known as type S, which is a combination of an automatic switch panel and main light panel with the battery change-over switch eliminated. The panel is so designed that the ampere hour meter panel type L can be readily connected in without interfering with the existing wiring. This equipment is especially designed for lighting baggage, express cars and other non-passenger carrying cars.

Automatic Panel Board, Type D

The terminal connections of the automatic cut-in and out switch and the battery change-over switch, as shown in Fig. 3, are so designed that the switch can readily be removed from the panel without interfering with the wiring. The automatic cut-in and out switch is fitted with carbon break pieces *A* of ample area. The top carbon is adjustable and care should be taken that this is the last contact to break; by loosening screw *B* the top carbon can be adjusted.

A careful inspection of Fig. 3 will show that the main brush *C* of the automatic cut-in and out switch is adjusted by the two screws *D*. The object of this is to introduce a shunt *E*, Fig. 4, across the series coil of this switch when the generator is delivering a predetermined output. This feature is particularly valuable in that only a fraction of an ampere of reverse current is required to throw off the brush when the automatic switch opens, the reason

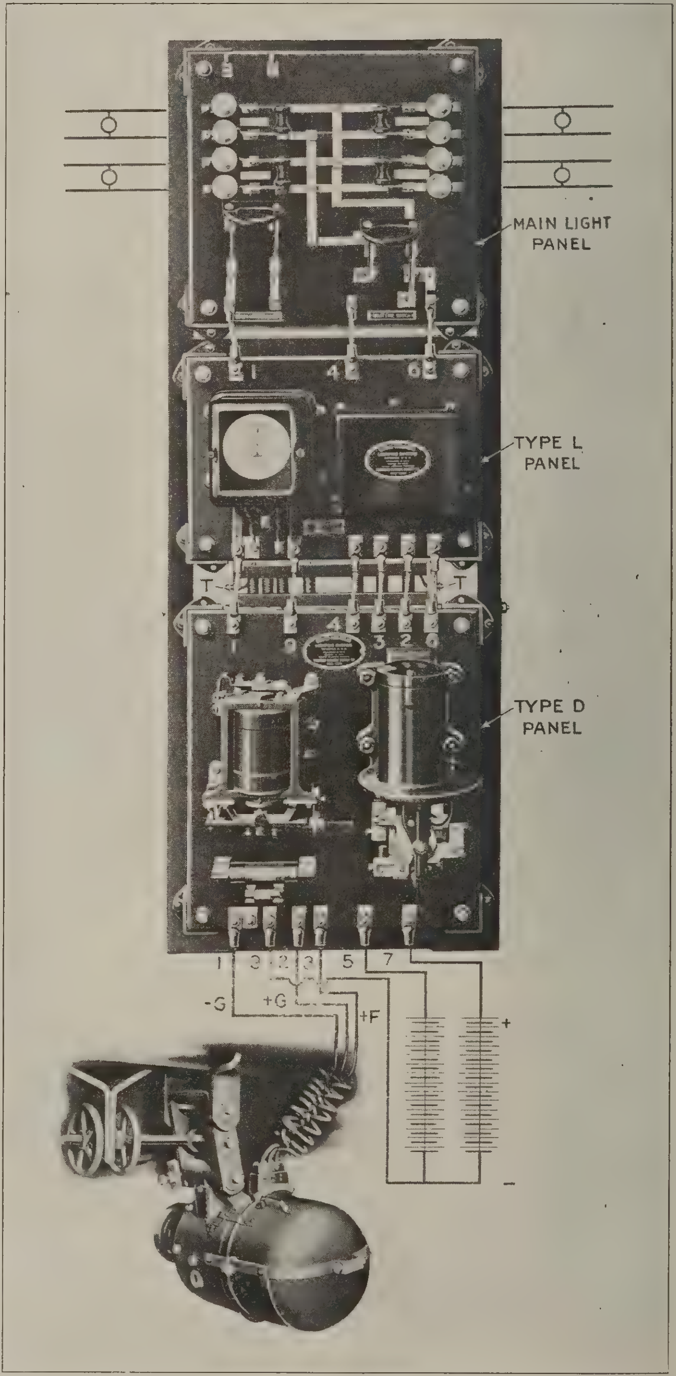

Fig. 1—Complete Switchboard for Stone-Franklin Car Lighting System

being that the series coil can be wound with a considerable number of turns in a limited space, due to the shunt carrying portion of the generator output. The result is that on cutting out, contact *F*, Fig. 3, is broken first. This then means that the series coil then carries all of the current from or to the generator. The comparatively great number of turns of the series coil, together with the special magnetic system described in Lesson 53, on page 436 of the July issue, insures that this automatic cut-in and out switch opens with a maximum discharge current of one-half to one ampere.

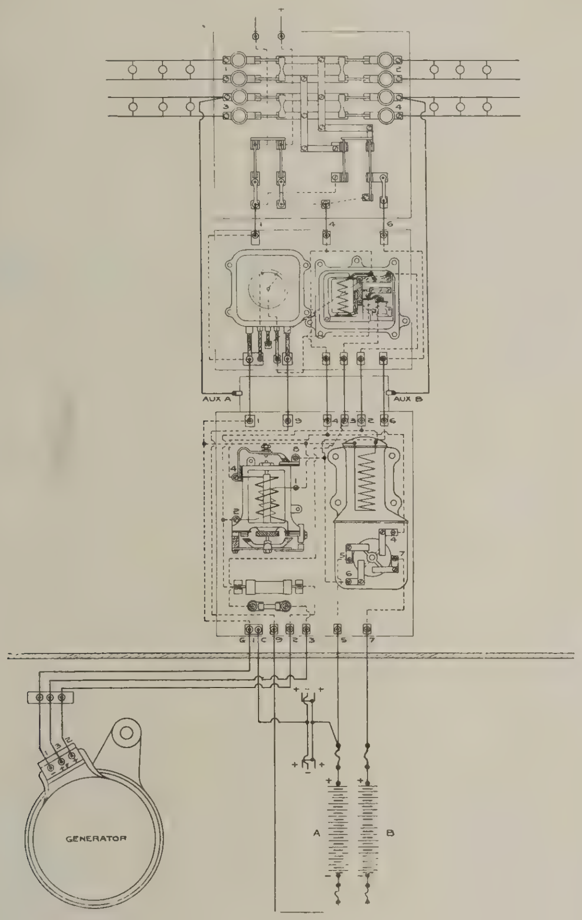

Fig. 2—Wiring Diagram of the Stone-Franklin Car Lighting Switchboard

Should necessity ever arise this switch can readily be removed from the panel by taking off the two fixing nuts *G*, Fig. 3, and removing the terminal screws *H*. The back view of the switch is shown as removed from the board in Fig. 4. In order to remove the plunger, remove screw *I*, Fig. 4, fixing main flexible lead to the movable portion of the switch, unscrew the knurled nut *J* after having loosened set screw *K*, Fig. 3, and remove the plunger entirely with main brush, as shown in Fig. 5.

To remove the series and shunt coils from the switch, remove resistance short circuiting brush *L*, Fig. 3, by taking out the two screws *M*, Fig. 5, loosen set screw *N*, Fig. 6, and unscrew top pole piece *O*, as shown in Fig. 6. The brass tube *P*, Fig. 7, which goes through the coils and surrounds the core can now be unscrewed from the lower portion of the switch casting. This tube is made just the length of the coils, so that it can easily be slipped into place, after which, in order to center it with the bottom part of the switch, it is threaded into the boss provided to take the knurled adjusting nut shown at *J*, Fig. 4. From this it is clear that in order to withdraw the coils, the brass tube must be unscrewed from the inside by means of the finger or a screw-driver handle, and is removed with the coils, as shown in Fig. 7. The coils are protected, top and bottom, by bakelite washers *R*, and the two coils of this switch are arranged so that the shunt coil fits snugly inside the series coil.

After necessary repairs have been made and switch has been carefully reassembled, the following test should be made. On lifting up plunger care should be taken that when carbon contact *A*, Fig. 3, closes, contact *S*, Fig. 3, should be about 1/16 in. from the top contact, and contact *F* should be ⅛ in. away from its top contact. In this manner it is insured that the shunt is connected across the series coil after the generator delivers a predetermined amount of current, so that the series coil can exert its pull on the switch before the shunt is introduced. It is seldom, however, that adjustments in this direction are necessary, since the brush is made symmetrical and upper or stationary portion of contact at *F* is higher by 1/16 in. than the similar contact plate on the right, thus making the air gap on the left twice as great as that on the right, thereby insuring that the left contact opens first, thus disconnecting the shunt across the series coil, making the coil very effective on a minimum reverse current which should not be more than one-half an ampere.

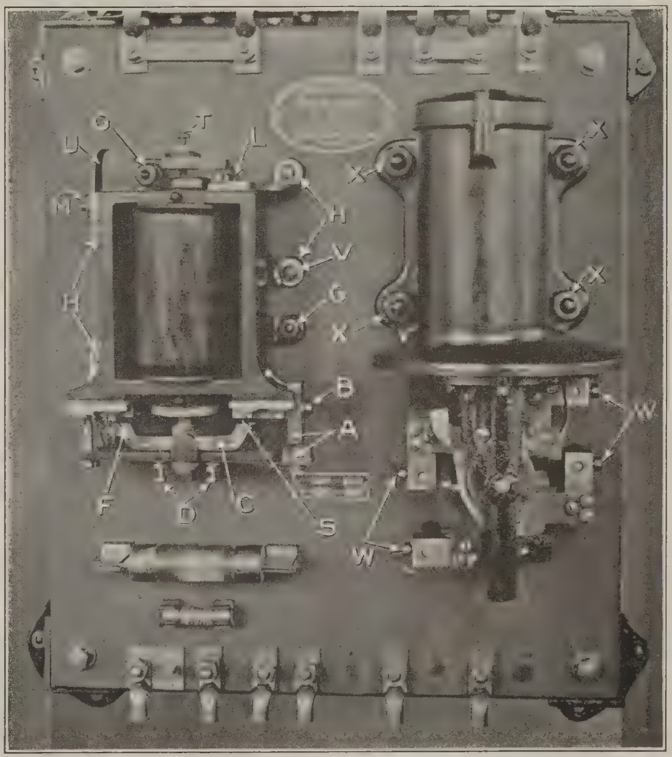

Fig. 3—Generator Control Panel Containing the Main Cut-In and Out Switch on the Left and the Battery Change-Over Switch on the Right.

The adjusting screw *T*, Fig. 3, on the top of the resistance short circuiting brush serves to calibrate the introduction and short circuiting of lamp resistance. The flat spring *U* serves to increase the tension at contact *T*.

Screw *V* fixes the negative shunt lead to the correct terminal, as shown in Fig. 3.

Battery Change-Over Switch

While it may probably never be necessary to remove the battery change-over switch, the construction of which is of extremely substantial design, it is well here to point out how this is accomplished. By loosening the four terminal screws *W*, Fig. 3, and removing the four nuts *X* from the fixing studs, the switch can be taken off the panel. To dismantle the switch entirely, remove the four contact brushes Y, as shown in Fig. 8. After this the bearing bracket *Z* is removed and the contact disc *A* complete can be taken out as shown in Fig. 9. The plunger *Q* is now free to be taken out from the bottom of the switch, as shown in Fig. 10, and by removing the top part of the core *B*, Fig. 10, the shunt coil can also be taken out. On re-assembling the switch, care should be taken that the contact disc *A* is so adjusted by means of the bearing screw *C*, Fig. 10, that the correct tension on these contact brushes is obtained.

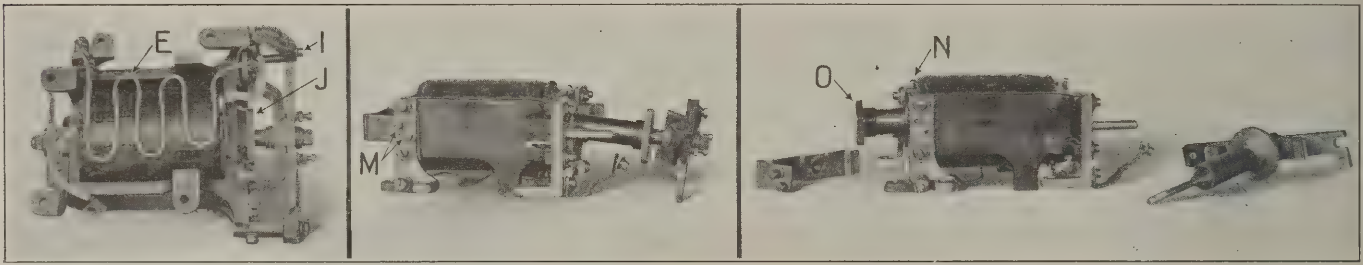

Fig. 4 Fig. 5 Fig. 6

The Illustrations Show the Various Stages in the Dismantling of the Main Cut-In and Out Switch. This Switch Completely Dismantled Is Shown in Fig. 7

In connection with the maintenance of battery change-over switch it is advisable to place a little vaseline on the surface of the contact disc at intervals of from three to four months. A little oil hole is provided in the front bearing of the spindle for the contact disc, through which, at equal intervals, a little oil should be inserted. The steel plunger is coppered to prevent rusting. The same is true of the plunger of the automatic cut-in and out switch.

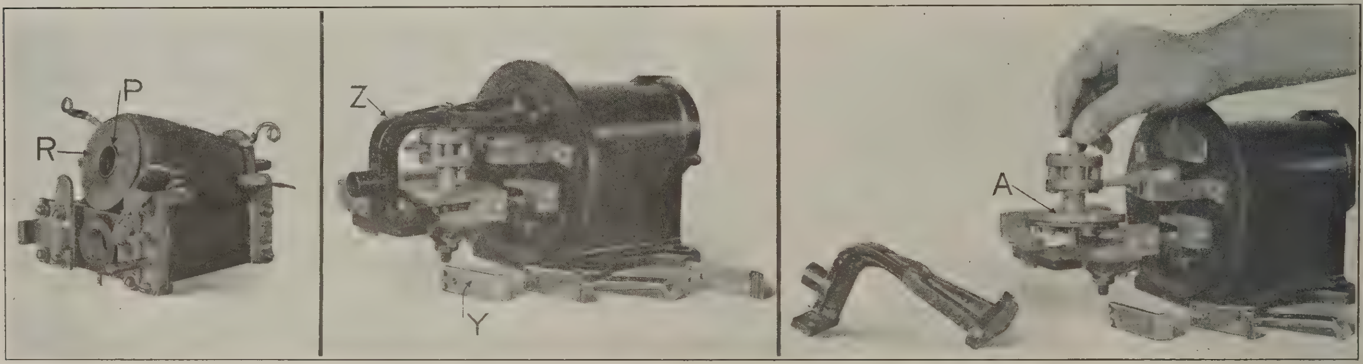

Fig. 7 Fig 8 Fig. 9

Showing the Main Cut-In and Out Switch Completely Dismantled and Two Stages in the Dismantling of the Battery Change-Over Switch

Terminal Connections

Finally, it may be of interest to study the terminal connections of these panels shown in Fig. 1. On the left hand side of panel *D* at the bottom we have No. 1 which connects directly to the main negative generator. This terminal, however, is fitted with two studs, the second one serving to connect the negative of the charging receptacle if it is required to read the separate charging of batteries on the ampere hour meter. If this is not required, the charging receptacle negative lead is directly connected to the battery negative. No. 9, the next terminal, is connected to the common negative of the batteries and this completes the negative side of the terminals. Terminal No. 2 leads directly to the positive of generator, and No. 3 accommodates the positive field wire. Terminals Nos. 5 and 7 are connected to the two positives of the two units of the storage battery.

The corresponding terminals at the top of the panel have been arranged to facilitate the general wiring of the complete system and in addition to that we have terminal No. 4 which feeds the lamp resistances, the lamp current being conducted away from terminal No. 6, so that terminal No. 4 can be called the 40-volt terminal, while No. 6, when the lamps are on, can be termed the 30-volt terminal. At each side of the resistance frame, fixed to the top of panel *D*, Fig. 1, there is a small terminal *T* which is connected to the positive side of certain individual lamp circuit switches on the switchboard so as to introduce the correct resistance in these lamp circuits. This insures that practically all of the lamp current is furnished by the generator and perfect lamp voltage regulation is obtained.

To test the battery change-over switch coil, remove the main fuse and push in automatic cut-in and out switch, which will operate the battery change-over switch if the solenoid coil is in order. Great care must be taken, however, that the main fuse is drawn before this test is made, as the closing of the automatic cut-in switch with the fuse in place, with the latest equipment, might cause a heavy current to flow through the armature from the batteries, the pole changer in the new equipment having been greatly simplified.

Lamp Resistances

The lamp resistances should be inspected periodically by switching on the lamps and lifting by hand the resistance short circuiting brush on top of the automatic cut-in and out switch. This will warm up the resistance tubes slightly and the maintenance man is thus insured of continuity.

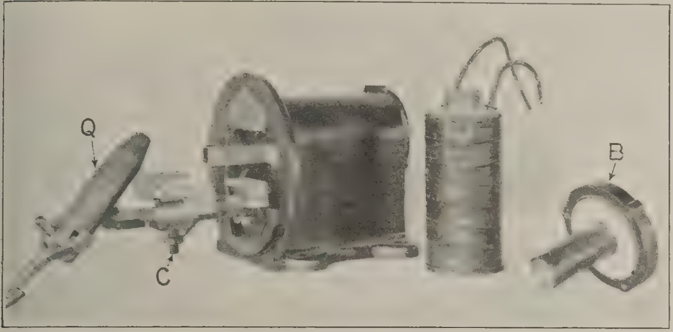

Fig. 10—The Battery Change-Over Switch Completely Dismantled

Ampere Hour Meter Panel, Type L

Very little need be said with reference to this panel, as the ampere hour meter can be readily removed by removing the four nuts from the fixing screws *D*, Fig. 11. Provision is also made for the connection of the thermocouple of the latest type ampere hour meter, as shown under the meter in Fig. 1. Since with the Stone-Franklin equipment the ampere hour meter is in the negative circuit, this thermo-couple connection must needs be on the battery positive side. The relay used in connection with the ampere hour meter, shown with cover removed in Fig. 11, serves to make the generator inoperative when the ampere hour meter hand reaches zero. The armature of the relay, which is gravity held, is fitted with a small flexible brush and carbon break, and serves to establish connection between terminals 2 and 3; in other words, between generator positive and generator field.

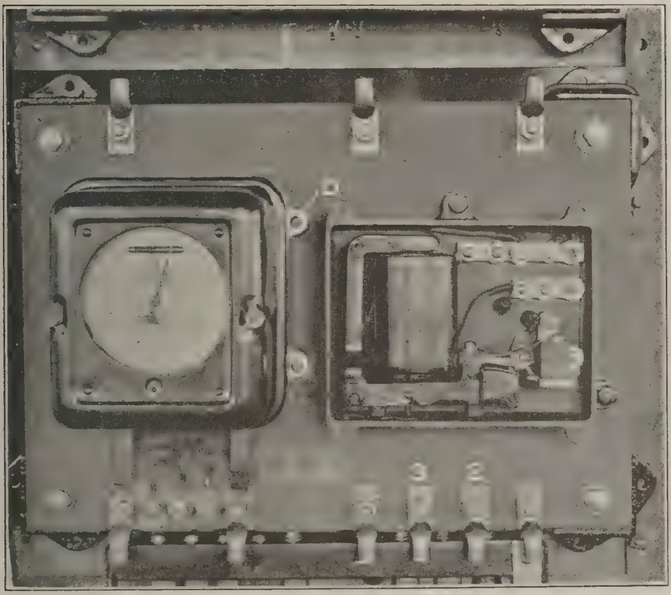

Fig. 11—The Ampere Hour Meter Control Panel Containing the Ampere Hour Meter with Its Relay

It is, therefore, clear that if at any time this panel should have to be removed for any reason, all that would be necessary would be to use a copper jumper between terminals 2 and 3 on a type *D* board, as well as a jumper between 1 and 9 on the top of the panel board, as shown in Fig. 7 on page 436 of the July issue, where the equipment is shown without ampere hour meter panel.

Main Light Switchboard

The main light switchboard panel furnished by the Franklin Railway Supply Company is a 4-circuit board for coaches, a 6 or 10 circuit board for dining cars, private cars, sleeping cars, parlor cars, etc. The panel is fitted with a double-pole single-throw train line switch and is connected to the 40-volt side of the equipment, so that any car trainlined to a Stone-Franklin equipment will be supplied with current at 40 volts pressure.

The main light switch is a double-pole double-throw switch of special design, which, in the "off" position, parallels the two units of the storage batteries. A little vaseline applied to the blades of these switches at intervals will tend to keep them in good service condition. Terminals on this switchboard are arranged to line up either with type *L* or type *D* board, so as to simplify the wiring of the complete switchboard.

ELECTRIFICATION OF NORWEGIAN RAILWAYS.—A beginning is soon to be made for the electrification of the State railways of Norway. The railway committee of the Storthing recently approved the proposal for the electrification of the line running from Christiania to Drammen, the estimated cost of which will be $6,520,000.

COPPER IN 1916.—It is estimated that 20 leading copper companies operating in the United States, Canada and South America produced approximately 895,000,000 lb. of copper in the first half of 1916. This is an increase of 299,000,000 lb., or 50 per cent over the first half of the year 1915.—*Iron Age.*

AEROPLANE EXPORTS FIVE MILLIONS.—Aeroplane exports for the fiscal year ended June 30, 1916, were 269, against 152 to June 30, 1915, and only 34 to June 30, 1914. The valuation of the exports of aeroplane parts for the fiscal year ended June 30, this year, was $4,843,610, but only $583,427 and $37,225 for the fiscal years of 1915 and 1914.—*Iron Age.*

ELECTRICAL BOOM.—So much has been said and written regarding the steel boom that the equal prosperity of the electrical industry has not received nearly the emphasis which its importance deserves. In the first nine months of 1916, the incoming orders booked by the three largest electrical corporations were at the rate of $354,000,000 per annum. This is 50 per cent more than the new business ever taken by these companies during the best previous year in their history, and is so far in excess of their productive capacity that total orders filled cannot possibly exceed $280,000,000. At least $75,000,000 of orders will be unfilled, or nearly 30 per cent of the probable 1916 shipments.—*Wall Street Journal.*

Practical Stunts

First Prize

An Armature Hand Press

The illustrations show a hand press for removing ball bearings from axle generator armature shafts and also for removing shafts from armatures. Axle generators for car lighting usually have the pulley end bearing forced upon the shaft under pressure and the shaft is usually forced in armature in a like manner. The hand press described herewith will quickly and safely remove these parts.

The sketch in Fig. 1 shows the hand press to be constructed from two 2 in. x 16 in. steel plates, four 1½ in. x 48 in. steel rods, one 2 in. x 8½ in. screw with 4 in. square head, one 1 in. x 30 in. steel handle bar and eight 1¼ in. hex. nuts.

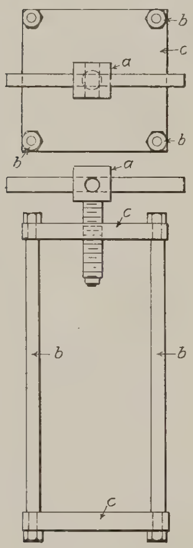

Fig. 1.

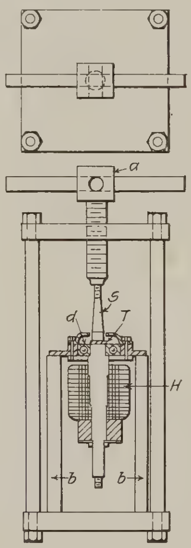

Fig. 2.

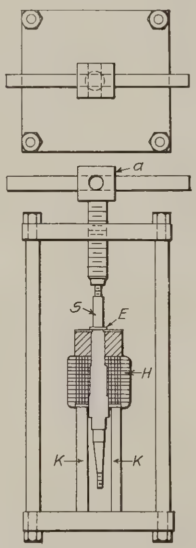

Fig. 3.

To remove a bearing from the shaft, suspend the armature with pulley end head complete from head flange upon two wooden uprights (b) Fig. 2, after removing thrust washer (t) Fig. 2 from armature shaft. Then by turning screw (a) Fig. 2, armature and shaft will be pressed in a downward direction free from head and bearing. Care should be exercised to have the two uprights (b) Fig. 2, the same length and screw (a) Fig. 2, and armature shaft (c) Fig. 2, in perfect line, before pressing off bearing, otherwise there is danger of bending armature shaft.

To remove armature shaft from armature, invert the armature in the press as shown in Fig. 3 resting core of armature H upon sleeve K. Then by removing thrust washer E, Fig. 3, and turning screw (a) the armature shaft will be pressed in a downward direction free from the armature.

The armature shaft and bearing can be replaced in like manner by using sleeves that fit over the shaft. This stunt is a time saver and eliminates the danger of damage possible with the old method of sledging or bumping.

Charles W. T. Stuart,
Penn. Electrician, Philadelphia, Pa.

Second Prize

Use of Storage Battery for Bells in Business Cars

In order to insure the reliable operation of electric bells in all business cars regardless of the condition of the dry battery which ordinarily furnishes the current required, the Illinois Central has decided to install double throw switches to enable the porter to throw the bell circuits on the storage battery, in series with two 40-watt lamps, when the dry batteries have become exhausted on the road. It is not practical to determine the condition of a dry battery by inspection or even by the length of time that it has been in service, so that it is not good practice to throw the batteries away at the end of certain periods because some of them might still contain a large portion of their original strength, depending on the service to which they have been subjected. It has, therefore, been the practice to use the dry batteries as long as current could be obtained from them and for this reason it was not an infrequent occurrence to have the dry batteries in business cars fail on the road.

The double throw switch, which is of the baby knife switch type, is installed in the switchboard locker in a vertical position and is so connected that when the handle is up the bells are on the dry cells and when the handle is down the bells are on the storage battery. Directly under the switch is located two No. 62569 Edison main line cutouts containing two 40-watt tungsten lamps connected in series with the connection going to the battery terminals on the lower part of the switchboard. The connections to the battery are so made that they will be independent of the lamp regulator.

Ordinarily, the switch will be up and on the dry cells but if the dry cells fail while the car is on the road, the switch can be thrown down thereby putting the bell system on the storage battery. The two 40-watt lamps in series in the storage battery circuit will reduce the current to about one half an ampere and in the event of a ground in the bell wiring system the current will still be small as it will have to pass through one of the lamps.

When installing this switch and the cutouts it is important to solder all connections to the bell circuit especially the leads from the main bell wires to the double throw switch. All screw heads on the switches and the cutout should also be carefully soldered. The switches cost about twenty-five cents each and the cutouts twelve cents, and as the installation is simple the total cost of providing such an emergency connection is small.

E. W. Jansen, Electrical Engineer,
Illinois Central, Chicago.

General News Section

The next meeting of the Electric Power Club will be held at the Homestead hotel, Hot Springs, Va., November 15, 16, 17 and 18, 1916.

The average installation of hydroelectric plants at the present time in first cost will amount to not less than $150 per kilowatt of capacity. A first-class steam plant today, depending on the size, costs from about $55 to $75 per kilowatt capacity.—*Journal of Electricity, Power and Gas.*

The Interstate Commerce Commission has announced a further hearing and oral argument at its office in Washington on October 30 on the commission's order requiring the equipment of locomotives with high power headlights, the effective date of which was recently postponed until January 1.

The Western Electric Company has moved its offices and show rooms in Buffalo from 98 Terrace to 709-711 Main street. The new location, with two large show windows fronting on as many streets, affords splendid display facilities, and the full line of Western Electric products will be carried. J. W. Tabb is the manager.

The Hess-Bright Manufacturing Company.—At a meeting of the Board of Directors of the Hess-Bright Manufacturing Company on October 6, B. D. Gray was elected president succeeding F. E. Bright. Mr. Bright remains identified with the company as chairman of the board.

The Edison Storage Battery Supply Company, through its manager, E. M. Cutting, announces that on account of its growing business and insufficient room at 441 Golden Gate avenue, it has secured the entire three floors and basement of building at 206-8-10 First street (near Howard), San Francisco, which it will occupy immediately as office, supply room and turbine station.

The Interstate Commerce Commission has issued an order postponing from October 1 to January 1, 1917, the effective date of its order of June 6 requiring the equipment of locomotives with high power headlights. Rules 29 and 31 of the order, referring to locomotives in road and yard service, are made applicable to all new steam locomotives put in service subsequently to January 1, and to all steam locomotives given general overhauling subsequent to January 1, and all steam locomotives subject to the rules are required to be equipped in conformity with the rules not later than January 1, 1920.

A New Electric Car Lighting Club in Boston

At a meeting of Boston car lighting men, held in the north station in Boston on Friday, Sept. 29, a new association, known as the Boston Car Lighting Association, was organized and the following officers elected: John J. Lambert, president; Harry Cappell, first vice-president; Wilson Crawford, second vice-president; Arthur Bennet, third vice-president; R. P. Whitcher, treasurer, and J. Callahan, secretary. The association expects to have a membership of at least 75, and will hold a regular meeting on the second and fourth Wednesdays of each month in a passenger coach in the North Central Station. The location of this car can be obtained by inquiring at the Pullman ticket office in the station.

Remote Control for Testing Laboratory

In a laboratory in which a large number and variety of electrical instruments are tested, it is important that means be provided for the rapid and accurate control of the electric generators which provide the current for testing. In Scientific Paper No. 291, by P. G. Agnew, W. H. Stannard, and J. L. Fearing, published by the Bureau of Standards, an elaborate system of this kind which is in use at the Bureau, is described. The control rheostats are not handled by the observers directly, but are operated by small motors which are controlled from any one of several laboratory rooms by means of small, multiple lever switches. Copies of this report will be ready for distribution in a few days.

The New York Car Lighting Association

The last meeting of the New York Electric Car Lighting Association, held on Tuesday, October 3, was marked by big doings. The members of the association gathered in room 1030 of the Grand Central station in New York, for the purpose of electing officers. After the ballots had been collected everyone adjourned to the banquet hall at a nearby restaurant where he found three large nicely decorated tables awaiting him. When everyone was seated Mr. Wall, president of the association, called the meeting to order and called for the secretary's and treasurer's reports. He then briefly outlined the program which has been arranged for the coming year, the special features of which provide for working exhibits and demonstrations of all types of car lighting systems. The nominating committee was then called on for its report and its chairman presented the following list of officers, which were all elected unanimously: Mr. Wall, president; Mr. Dunlap, first vice-president; Mr. Prettyman, second vice-president; Mr. Scudder, secretary; Mr. Case, treasurer, and Messrs. Leitner, Rooney, Seaman and Stoker, members of the executive committee. This concluded the evening's business so that from that time on the undivided attention of all the members was turned to the splendid banquet which had been prepared.

To date the following definite arrangement has been made by the program committee: November 14, a demonstration of the Stone-Franklin car lighting system; December 5, a discussion of the Stone-Franklin system by the members at which time all questions will be answered; January 2, a demonstration of the Gould or the U. S. L. system; February 6, questions on the system that was described in January.

Personals

Lester B. Knight has been appointed eastern representative railway department, Willard Storage Battery Company at New York city. He was employed by the New York Central at West Albany in 1906 and went with the Boston & Albany in 1907. In 1912 he left the B. & A. and went with the Hall Signal Company, which was installing signals on same road. After completion of signal work he went with the B. & A. as chief electrician of electric car lighting.

E. L. Myers was appointed western representative railway department, Willard Storage Battery Company, with headquarters in Chicago, and embracing all territory west of the Ohio and Mississippi rivers, on April 1, 1916. Mr. Myers was employed by the Western Union Telegraph Company and the Santa Fe from 1887 to 1900, as division lineman and construction foreman on the Pacific Coast. During the year 1900 he was on construction work for electric light and telephone companies in El Paso, Texas, and from 1901 to 1909, was general foreman of telegraph construction for the Mexican Central. From 1909 to 1913, he was chief electrician for the National Railways of Mexico and from December 1, 1913, to present time has been with the Willard Storage Battery Company.

Jos. A. Andreucetti has been appointed assistant electrical engineer of the Chicago & North Western with headquarters at Chicago, Ill. Mr. Andreucetti was born in the city of Chicago, on May 1, 1881, and after finishing his high school course in that city, took up the study of business and commercial law. He then entered the operating department of the Illinois Central, where he remained from 1899 to 1903. Mr. Andreucetti then began the study of electrical engineering with the International Correspondence School of Scranton, Pa., taking a complete course in electrical and mechanical engineering. He also attended lectures at the Lewis Institute and night school classes in electricity in Chicago. Mr. Andreucetti entered the employ of the Chicago & North Western as electrical helper in the electrical engineering department under A. J. Farrelly and, step by step, was advanced to the position of wireman and inspector, acting foreman of electrical construction, foreman of electrical construction, general foreman, and finally, assistant electrical engineer of the entire system.

Jos. A. Andreucetti

Mr. Andreucetti has always been keenly interested in the Association of Railway Electrical Engineers, and since October, 1910, he has each year been unanimously elected secretary-treasurer of this association. Mr. Andreucetti deserves great credit for the manner in which he has handled his share of the association work during the time he has been secretary, no one having the success of the association more at heart than he. Mr. Andreucetti also belongs to the Masonic order, to the Jovian League, the Electric Club and to the Master Car Builders' Association.

Edward Wray, who has been identified with the *Railway Electrical Engineer* since it was organized in 1909, in the various capacities of editor, owner and business manager, has accepted the position of assistant to R. C. Lanphier, general manager of the Sangamo Electric Company, with headquarters at Springfield, Ill. Mr. Wray was born in Janesville, Wis., in 1884 and was graduated from the University of Wisconsin in 1905 from the course in electric chemistry. After finishing the regular four-year course, he took another year of post graduate work and received the degree of electrical engineer in 1906. During the year of post graduate work at the University of Wisconsin, Mr. Wray had charge of a series of tests on railway car lighting equipment which was participated in by ten senior students of the university. On this work he traveled approximately 25,000 miles and tested all of the various methods of electric car lighting in use at that time. The report of this investigation was published by the university as one of their official bulletins under the title of "Methods of Train Lighting." After leaving school Mr. Wray went with the J. G. White & Co., of New York, where he spent the first six months on inspection and design of electric power plants. He was then sent to Porto Rico in connection with the Caguas Railway extension, where he remained until April, 1908. During this time he held the position of rodman, levelman, transitman, topographer and assistant engineer. Upon returning to New York he entered the employ of D. C. & William D. Jackson, engineers of Boston, and was engaged in the work of appraising the New England Telephone Companies' properties until November, 1908. Mr. Wray then returned home upon the death of his father and until May, 1909, was engaged as assistant manager of the Janesville (Wis.) Electric Company.

Edward Wray

About this time, he got in touch with L. B. McKenzie, who was then publisher of The Signal Engineer. Mr. McKenzie explained to Mr. Wray that the Association of Railway Electrical Engineers had requested him to start a new magazine devoted exclusively to the interests of electricity on railroads and Mr. Wray was offered the editorship on the new paper, which he immediately accepted. That was the beginning of the *Railway Electrical Engineer*. One year later when The Signal Engineer was purchased by the Simmons-Boardman Publishing Company, Mr. Wray organized the Wray Publishing Company and purchased the *Railway Electrical Engineer* from the McKenzie Publishing Company. The

Railway Electrical Engineer was again sold to the Simmons-Boardman Publishing Company in October, 1915, and was moved to New York.

T. V. Buckwalter

T. V. **Buckwalter** was appointed chief engineer of the Timkin Roller Bearing Company, Canton, Ohio., on September 18. Mr. Buckwalter was graduated from Woodward High School, Houtzdale, Pa., in 1896, and shortly afterwards entered an apprentice course with an electrical engineer in Philadelphia. He served two years as electrician with the Pneumatic Steel Company, Freehold, N. J., and in 1900 entered the employ of the Pennsylvania Railroad Company at Altoona machine shop as electrical machinist. From 1901 to 1906, Mr. Buckwalter had charge of the electrification of large machine tools and the erection of special electrical machinery. In 1906 he was transferred to the electrical engineering drawing-room as a draftsman and was later promoted to foreman in charge of development of electric industrial trucks, gas and electric tractors and research work on automobile problems as affecting the railroads. Mr. Buckwalter made a special study of selfpropelled vehicles for use on rails and of machinery for handling material in railroad enclosure. It will be remembered in this connection that Mr. Buckwalter supervised the design and the construction of the electric tractor used in Jersey City to handle freight cars on city streets. This tractor was completely described in the *Railway Electriccal Engineer* for November, 1913, and June, 1916.

Mr. Buckwalter has always been a most active member of the Association of Railway Electrical Engineers, having served on many of its committees, and is also a member of the other following societies: American Society of Mechanical Engineers, Society of Automobile Engineers and Electric Vehicle Section of the National Electric Lighting Association.

I. R. **Wentworth**, formerly in charge of electric car lighting at Chicago Terminal, for the New York Central, has entered the services of the Willard Storage Battery Company, as representative of railway department, Chicago branch. Mr. Wentworth received his train lighting experience with the Consolidated Railway Electric Lighting & Equipment Company between 1913 and 1916. From 1906 to December, 1907, he was with the Chicago & Alton, and the old Bliss Car Lighting Company, and from December, 1907, to 1909, was electrical inspector for the Lake Shore & Michigan Central. From 1909 to 1916 he was electrician foreman in charge of train lighting at Chicago for the New York Central and on September 16, 1916, he entered the services of the Willard Storage Battery Company.

Harry H. **Gribben**, superintendent of the Oakland, Cal., factory of the Standard Underground Cable Company, died suddenly September 25, at his home in Oakland, California, age 56 years, 8 months and 7 days. Mr. Gribben was a native of Pittsburgh, Pennsylvania, and lived there until 1899, when he moved to California to take charge of the factory which the Standard Company had then just completed. Previous to this he was general foreman in the company's Pittsburgh factory. He had been in the employ of the Standard Company for over 30 years and was one of its most faithful, loyal and competent superintendents, and a man who by his personal qualities endeared himself not only to his business associates but to every one with whom he came in contact.

F. W. Reed

F. W. **Reed**, as briefly announced in the September issue of the *Railway Electrical Engineer,* has been appointed chief electrician of the Northern Pacific Railway Company, with headquarters at St. Paul, Minn. Mr. Reed was born in Chicago in 1879, and after completing his public school education, started his electrical training with a wiring contractor in the same city. In 1898 he went with the Pullman Car Company as a car wireman. In the latter part of 1899, the Northern Pacific Railway Company decided to wire some of its cars for electric lights and as it desired some one familiar with that kind of work to take charge of it, it asked the Pullman Company to recommend such a man. The Pullman Company recommended Mr. Reed, who finally went with the Northern Pacific on January 3, 1900, as foreman electrician at the Como passenger car repair shops in St. Paul, Minn., where he installed the first electric train lighting equipments used on the Northern Pacific. While at the Como shops, Mr. Reed also had charge of the gas lighting equipments on the cars and from 1904 to 1908 inclusive, was in entire charge of the steam power plant in addition to the duties previously mentioned, having during that time the title of chief engineer. In 1908, Mr. Reed left the Northern Pacific to install and take charge of the steam and electric power equipment for a Montana mining company and later accepted a position with the city of Glasgow, Mont., as superintendent of the electric light and power department. Mr. Reed returned to the Northern Pacific Railway Company in 1911 as foreman electrician in charge of electrical construction work. In 1913, he was appointed general foreman electrician in charge of electrical construction work on the entire system and in this capacity also handled a large part of the electrical engineering work, assisting the mechanical engineer and the chief electrician. On July 1, 1916, he was appointed chief electrician in direct charge of all electrical construction work and electric train lighting and with general supervision over all electrical maintenance on the system. As chief electrician, Mr. Reed will also take care of the general electrical engineering work for the Northern Pacific, in this connection assisting W. J. Bohan, mechanical engineer. In addition to the above duties Mr. Reed will have general supervision of all steam electric power plants on the system, work which he is particularly well fitted for through his experience as chief engineer of the power plant at the Como shops, St. Paul, together with his work as chief engineer of steam power plants in Montana.

J. H. Bryan

J. H. Bryan has been appointed business representative of the *Railway Electrical Engineer* succeeding Edward Wray, whose resignation is announced in another part of these columns. Mr. Bryan, who was born in Goldsboro, N. C., was graduated from North Carolina Agricultural and Mechanical College in 1903 with the degree of Bachelor of Engineering in Mechanical Engineering, and in 1913 he received the degree of Mechanical Engineering from the same college. He was in the employ of the General Electric Company, construction department, during the six months from June, 1908, to December, 1908, and from December, 1908, to November, 1910, he was in central station work as engineer and superintendent. In November, 1910, Mr. Bryan became connected with the Westinghouse interests, spending one year in the manufacturing department of the Westinghouse Machine Company and five years in the Industrial Sales department of the Westinghouse Electric & Manufacturing Company, where he handled electrical equipment for steam railroad shops. During this time Mr. Bryan made a special study of electric arc welding and also of the application of direct motor drive and automatic control to railroad shop machine tools. Mr. Bryan left the Westinghouse Electric & Manufacturing Company to come with the Simmons-Boardman Publishing Company on October 1, where he will act as business representative for both the *Railway Electrical Engineer* and the Railway Maintenance Engineer.

Railway Structures

The St. Louis & San Francisco contemplates the installation of a 10-stall roundhouse, a 100-ft. turntable, mechanical department buildings and yard tracks, to cost about $200,000, in Oklahoma City, Okla.

The New York, New Haven & Hartford will spend about $250,000 in improvements to freight and passenger terminals at New Haven, Conn. Definite plans are not yet made.

The Buffalo, Rochester & Pittsburgh has placed its name, in conspicuous lettering, on all overhead bridges where state highways cross the railroad; this for the purpose of giving people in automobiles a convenient landmark and to make the name of the road familiar.

The Pennsylvania Railroad will start work shortly on a 14-stall roundhouse at Derry, Pa., costing about $75,000. The structure will be of brick and wood, and will have a wood block floor, wood rolling doors and built up roofing. The work will be carried out by W. F. Trimble & Sons Company, Pittsburgh, Pa.

The Erie is carrying out improvements on County road, Secaucus, N. J., at a cost of $650,000. The work calls for the construction of a 36-stall roundhouse, to have 115-ft. stalls and a 100-ft. turntable, a machine shop, a power house, a storehouse and a complete engine terminal. The foundations of the buildings will be of concrete. The superstructures of the roundhouse and machine shop will be of frame construction and the power house of tile. The contract for the work has been given to the Robert Grace Contracting Company, Pittsburgh, Pa.

Trade Publications

Storage Batteries.—One of the latest publications of the Electric Storage Battery Company, Philadelphia, bulletin No. 159, deals with the Ironclad-Exide battery for storage battery, mine and industrial locomotives. The booklet describes the batteries themselves and contains a score of views of storage battery locomotives.

Welding and Cutting.—The Searchlight Company, Chicago, is now distributing catalogue No. 12 on Searchlight welding and cutting equipment. The booklet, to quote from its title page, is "A book of specific information on the welding and cutting of metals by the oxy-acetylene process, together with a catalogue of the equipment necessary for such work." There are many illustrations showing the Searchlight equipment and the work for which it is adapted.

Lincoln Motors is the title of a booklet just issued by the Lincoln Electric Company, Cleveland, Ohio. Besides describing the various types of Lincoln motors with the aid of numerous illustrations, showing the details of construction and assembly, it gives considerable information regarding special applications of these motors in various industrial plants and shops. The Lincoln arc welder and the Lincoln storage battery charger are also described and illustrated.

On the Firing Line With Battery Bill.—The story of W. Alkaline Battery, otherwise known as Battery Bill, has now been published in booklet form by Battery Bill's employer, the Edison Storage Battery Company, Orange, N. J. Battery Bill is already well known to readers of the advertising pages of the *Railway Electrical Engineer*. He is the enterprising salesman of Edison storage batteries whose adventures, detailed in the form of letters to his boss, center around his successful attempt to sell Edison batteries to the X. Y. Z. Railroad and to help the officers of that road answer the query of President X: "Why aren't we using Edison batteries?"

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Mechanical Design of Electric Locomotives

The features which determine the success or failure of an electric locomotive design are usually considered to lie in the electrical equipment. An exaggeration of this attitude led to some serious mechanical difficulties in early designs, but it is now recognized that it is no simple matter to devise a running gear for an electric locomotive to give the same satisfaction that has been obtained by nearly a century of development of steam-driven equipment.

A paper by A. F. Batchelder, published in another part of this issue, on the mechanical design of electric locomotives, presents a unique analysis of the stresses produced on the track by a locomotive rounding a curve or swaying from side to side on tangent track, and gives a new insight into the difficulties encountered by the designer. The discussion on relative efficiencies of different types of driving gear and on the advantages of simplicity should furnish food for thought for some designers who apparently do not consider such features. In view of the numerous discussions in recent years concerning the importance of a high center of gravity, particular attention is called to the author's opinion that an electric locomotive can be designed for high speed with safety, regardless of the height of the center of gravity.

Convention Activity

As in past years the burden of the discussion at the Chicago convention this year was borne by a few of the older men with hardly any exceptions. The men who actively took part in the discussions this year were the same men who have done so at previous conventions; for the good of the younger members we hope this condition will not be repeated next year. E. W. Pratt, ex-president of the Master Mechanics' Association, in his address before the convention at Atlantic City last June very ably pointed out the value of having the younger members actively participate in the affairs of the association which, of course, includes the discussion of the committee reports. It is his suggestion that the officer in charge of the mechanical department should tell his men in plain words that he wants them not only to learn all they can by their attendance at the convention, but also to contribute of their experience for the benefit of others. He stated that when he first attended the convention, he was told by a wise counselor that he must take some part, no matter how small, in the discussion, and it was his idea that more would be accomplished for the good of the association if, at the close of the convention, it could be said that every member present had made a few remarks on some subject than if it could be said that a few of the most prominent orators had discoursed ever so eloquently.

There is no better way to get the younger men of the association interested in its affairs than to give them some responsible work to do in connection with the work of the various committees. For this reason, the executive committee would do well to make a special effort to enlist the services of the younger men and require that they act on the various committees so that their work and their experience will be of benefit to all. The future of the association lies in its younger members and it would be a mistake to overlook them entirely until the older members, who have been carrying the major work of the association on their shoulders, have finally fallen out. It is of especial importance that the younger men and the new members quickly get into the habit of rising to their feet on the convention floor and actively enter into the discussion of the reports.

Headlights and Other Things

The hearing before the Interstate Commerce Commission, which has been conducted at Washington for over a week, concerning the recent order of the commission that all railroads must equip their locomotives with high power headlights, has unexpectedly brought to light the severe methods employed by the Brotherhood of Locomotive Engineers in punishing its members who have dared to go against the recommendations of the brotherhood's legislative committee by testifying against the use of high power electric headlights on locomotives, or even to give verbal or written opinions on this matter to members of the commission or to railroad officers, if such opinions were at variance with those held by the higher officers of the brotherhood.

The testimony bearing on this phase of the subject, which was finally admitted by the Interstate Commerce Commission, because as Examiner Hines announced, the commission was interested in being advised with respect to deterrent influence brought to bear upon witnesses, showed that some engineers have been expelled from the brotherhood and have been ostracized by their fellow employees at the command of the chief executive of the brotherhood for expressing their views as stated above.

On another page of this issue will be found an abstract of the Interstate Commerce Commission hearing at Washington, including a section from the constitution of the Brotherhood of Locomotive Engineers which refers to the penalty dealt out to members of the organization who interfere with national legislative matters and who refuse to sustain the official acts or instructions of the legislative board. It does not seem possible that such an important organization would dare to completely subordinate its members to the dictates of a handful of its officers in matters so vital to their welfare. While Congress was considering the passage of laws to avert a general railroad strike recently, it was understood that the officers of the brotherhood were resolutely against any method of compulsory arbitration on the grounds that such legislation would simply mean a condition of slavery for the members of the brotherhood. In the light of recent events and of the evidence submitted during the hearing on the headlight question at Washington, this claim on the part of the brotherhood officers appears ridiculous, as by the provisions of its own constitution the brotherhood members are not very far removed from a condition of slavery; the situation in the brotherhood can at least be called a reign of terror. Considering the facts that have been brought to light the reputed strength of the brotherhood does not seem so formidable, and the result of the disclosures in regard to the methods of coercion employed in this organization will undoubtedly open the eyes of a good many people, especially members of our Congress who were heretofore of the opinion that the recommendations made by the legislative board of the brotherhood voiced the opinions of the majority of its members. For this reason it is not at all certain that the locomotive engineers themselves, who have always been looked to as its champions, actually desire the high power electric headlight on their locomotives. On western roads, which operate long stretches of single track, conditions are such that the use of high power headlights is warranted, but the time seems to have arrived when it will be expedient for the officers of the brotherhood to realize that there are railroads in the United States which operate under conditions where the use of high power electric headlights would prove a serious menace to the safety of high speed trains.

The Character of Committee Reports

It has been our pleasure from time to time to call attention to the excellence of some of the reports presented at the conventions of the Association of Railway Electrical Engineers. The reports this year that are particularly good are those presented by the committees on illumination, car lighting and shop practice. It is unfortunate, however, that all of the committee work is not of the same high character as those mentioned, probably due to the fact that in a great many cases the committee chairmen have not received the proper co-operation from their fellow committeemen. It is regrettable that it seems to be considered good practice to allow the chairman to assume the burden of doing all the committee work himself, and of getting out the report, the other members of the committee simply assuming that they do their share when they allow their names to be signed to the report. It is evidently the duty of each committee member not only to take active part in the committee work but also to enter into a discussion of the report on the convention floor so that it will be distinctly understood that the report embodies the views of the majority of the committee. It is only when all the members enter wholeheartedly into the work assigned that original and commendable work can be done; the complete job of getting out a report which will do justice to the association is too much for any one man. With few exceptions the work which has been assigned to the various committees has been of great importance and when committee work is worth doing it is worth doing well; such work should include a great deal of original work on the part of each member. The practice of basing reports on replies from circular letters and even from practices pertaining to that which is standard on the roads of the individual members does not always represent the high class of work that the committee is capable of doing if original methods were employed and if original experiments were made.

There is also too much of the practice of waiting until the last minute before the committee work is started; then as the time draws near for sending in the complete report the temptation is great to pull some specifications out of the file and with a few supplementary remarks send it along to the secretary. It is extremely important that all committee work be outlined as soon as possible after it has been assigned so that the work of the committee can be intelligently distributed among its members in time for them to prepare their plans and do whatever original work is necessary.

What Regenerative Braking Really Is

II

By A. J. Manson

LAST month we dealt with regenerative braking as applied to electric locomotives operated with direct current, now we come to consider electric locomotives equipped for alternating current operation. The same conditions with regard to pressure apply equally well to the alternating current single-phase series locomotives as to the other group. The single-phase system and the single-phase motor are, however, much better adapted to regeneration than the direct current series motor, due greatly to the fact that the motor itself is not as sensitive as the direct current series motor is.

The system uses high voltage for the overhead wire, usually 11,000 volts. This is much too high for direct application to the motors so it is necessary to use a piece of electrical apparatus known as a "transformer" to step down from 11,000 volts to a voltage suitable for the motors. The transformer consists of a series of coils placed adjacent to each other and surrounded by an iron laminated core and, as the word implies, transforms the electric high voltage to the low voltage. By means of taps or leads brought out from the transformer coils, any low voltage desired can be obtained.

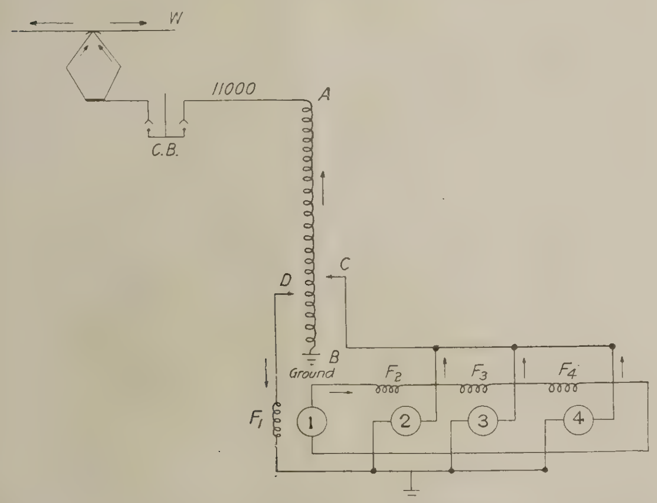

Fig. 1. Diagrammatic Connection for Regeneration with Single-Phase Alternating Current

Referring to Fig. 1, if 11,000 volts is applied at the lead *A* of the transformer which is represented by the loops as shown, a small amount of current, known as "exciting current," would flow through the coils and out of the lead *B*, which is connected to the ground *Grd.* If it were possible to measure the voltage beginning at lead *A* throughout all of the turns of the transformer, it would be found that there was a decrease in voltage as progress was made along the coils from *A* toward *B* until zero voltage was obtained at *B*. Thus it is possible to get any value of voltage desired by connecting to the coil at the proper point, a cable which can be brought out of the case. This cable is known as a tap.

For regeneration connections and circuits the motor-generator set can be used as in the direct current arrangement if desired, but another satisfactory arrangement and one especially suitable for alternating current single-phase operation is one where one motor of the four on the locomotive is used as a generator for furnishing current to excite the fields of the other three; the three motors sending power back to the line. Referring again to Fig. 1, motor No. 1 is used as the generator and furnishes current through the fields *F2, F3* and *F4*; motor armatures 2, 3 and 4 generating current which is passed back into the transformer through the lead *C*.

As the locomotive speed decreases the voltage from the motors can always be kept as a sufficient value to regenerate, by putting more current through the fields of these motors. This is accomplished by increasing the strength of the field of the motor used as a generator *F1*, thus causing No. 1 motor to generate more current for the other three fields. This is easily accomplished by connecting the lead *D* to a suitable higher voltage tap in the transformer. Even after the maximum excitation is reached, due to the fact that lead *D* has been connected to the highest tap, the lower voltage which is generated by the motors can still be used, as lead *C* can be moved to a lower tap, thereby increasing the ratio $\frac{AB}{CD}$ so that this lower voltage still gives the necessary increase of pressure over 11,000 volts to force current back into the line wire.

Three-phase Motors

We have seen that it is possible to regenerate with both the direct current and single-phase systems, providing that certain changes in the motor connections are made to give them the necessary shunt characteristics and further provided that a motor-generator set or one of the driving motors is used for exciting the shunt fields. Regeneration with these two systems works satisfactorily, but as far as simplicity and reliability are concerned, the locomotives driven by the three-phase or polyphase motors are superior. The polyphase motor is a constant speed type and its speed does not depend upon the voltage of the circuit, but upon the frequency of the power supply, so that for a given frequency there is a certain motor speed known as the synchronous speed. Frequency is usually expressed in terms of "cycles"; for instance, 25 cycles or 60 cycles. Alternating current does not give a constant pressure like direct current, but changes in value. Starting at zero, it progresses to a maximum, then decreases to zero, reverses, goes down to an equivalent negative maximum and returns again to zero; all this takes place in the fraction of a second.

The induction motor consists of a stationary winding, which is continuous on the inside of the frame, and a rotating armature. This armature has no connections whatsoever with the stationary winding or with the power supply circuit. That is, the power connected to the motor is connected only to the stationary winding on the frame. With the three-phase induction motor used on most of the three-phase electric locomotives and which are used on the Norfolk & Western locomotives, the power, when connected to the winding around the frame of the motor, produces a magnetic field which rotates in this winding at a speed depending upon the frequency of the supply circuit (usually 25 cycles for electric traction) and upon the number of poles of the motor. The revolving field passing by the winding on the armature, known as the "rotor," induces a current in it which tends to stop the rotation of the field or poles. As the rotating field cannot stop, the rotor is dragged along at practically the same speed, there being a slight slip depending upon the load or the work which the motors are doing. When the rotor is running in exact step with the rotation in the stationary winding of the motor, known as the "stator," it is running at what is known as "synchronous speed."

Regeneration with Three-Phase Motor

When regeneration takes place the rotor runs at a speed slightly above the synchronous speed of the stator field. For this reason and because the electrical supply is still connected to the primary winding of the stator, the rotor conductors overtake and therefore cut the lines of force of the revolving stator field and current is generated in the rotor windings in the opposite direction. The rotor flux created by the reverse current flowing in the rotor affects the flux in the primary or stator windings and generates in them a flux to oppose rotation. The reversal of the flux in the primary causes a reversal of the primary current, and hence power is delivered to the line. At the same time the rotor flux tends to bring the rotor speed back to that of the magnetic field, and, therefore, offers resistance and supplies the necessary energy or breaking effect to hold the motors on the grade. To simplify this explanation, a simple illustration of the primary and secondary circuits of a transformer is shown in Fig. 2. The secondary (rotor) is connected to a motor and the primary (stator) to the line supply. As a load is put on the motor end, current passes through the secondary winding and a flux is set up which opposes the flux generated in the iron core by the primary current and additional high tension current is necessary to flow through the primary windings to overcome the secondary flux. If the motor is made a generator and speeded up so as to give a higher voltage, the current will be reversed in the secondary winding, the secondary flux will be reversed and a primary flux will be set up to oppose this secondary flux. In order to set up this opposing flux in the primary, a reversal of current is necessary and hence power is put back into the line supply. It is thus not a question of generating a voltage to overcome the line wire voltage, as in the case of the direct current and single-phase series systems, but it is purely a question of speed of rotation and a condition which takes place automatically without any change in the motor circuit. It therefore follows that there is no appreciable variation in the speed with regeneration, when using three-phase motors.

The use of a phase-converter in the locomotive to enable the three-phase motor to operate from a single overhead trolley or a single-phase supply, does not in any way change the automatic feature of the regenerative braking. This latter arrangement is that used on the Norfolk & Western locomotives, and the description of the handling of these motors in the first part of this article, printed in the September, 1916, issue, points out how simple and automatic the three-phase motor works.

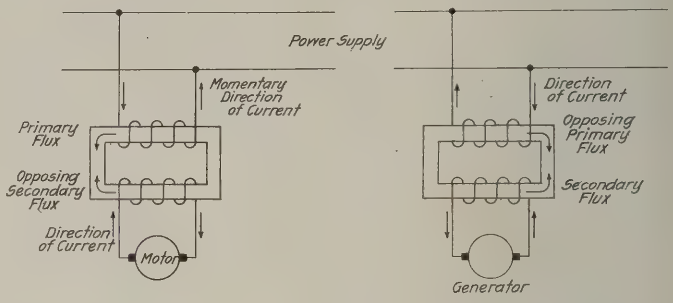

Fig. 2. Two Transformer Diagrams Showing the Relations Between Current and Core Flux When the Secondary Is Connected to a Motor and When It Is Connected to a Generator. By Thus Comparing the 3-Phase Motor to a Transformer, It Is Easier to Understand How the 3-Phase Motor Helps the Current Back Into the Line When It Is Driven Above Synchronous Speed.

Advantages Claimed for Regeneration

The question naturally follows, what are the advantages to be gained by the use of regeneration? They are many, and can be classified as follows: 1. Brake-shoes and wheels. 2. Speed down grade. 3. Air-brakes, brake rigging, draft gear. 4. Power house. 5. Safety.

With regard to brake-shoes and wheels, the energy stored up in a heavy freight train descending a grade is large, and with only the air-brake available as a means of "letting the load down the mountain," this energy must be dissipated as heat at the brake-shoes, which results in rapid wear of the shoes, and often the overheating and heavy wear of the wheels, with risk of loose and broken tires and rims. Regenerative braking is in use on electric locomotives of the Italian State Railway, and the average life of the brake-shoe has been increased from 4,500 miles to over 14,000 miles, and a corresponding increase in the life of the wheels.

The speed of a heavy train down the grade is often limited by the permissible heating of the brake-shoes, so that, with regeneration, the speed can be the safe speed for the track, curves and construction of rolling stock if it is so desired. The taking of a heavy train down the grade not only imposes severe duties on the shoes and wheels, but also on the air-brakes and draft gear as well. The saving in maintenance of rolling stock due to regeneration is considerable.

When we come to the power house, we find the saving in horsepower output by regeneration depends upon the operating conditions and the grade encountered. With, say, all grades on the road of approximately 2 per cent it might be possible to save 50 per cent in power consumption, while with the average mountain conditions the saving would probably not exceed 25 per cent. Even with no saving shown in the power house output, the simplicity and reliability of operation are not sacrificed by regeneration, and the advantages mentioned above, even disregarding the interest of safety, make it worth while.

Mechanical Design of Electric Locomotives*

By A. F. Batchelder

THE purpose of this paper is to bring to the attention of the Society some of the important features in the mechanical design of electric locomotives, with a view of having a more common understanding of the requirements and the method of meeting them. These features may be listed in the order of their importance as follows:

1—Safety of operation
2—Adaptability to service conditions
3—Reliability in service
4—Convenience of arrangement as affecting safety and efficiency of operation
5—Power efficiency (affected by mechanical design)
6—Service time factor (ratio, time available for service to total time)
7—Cost maintenance of permanent way
8—Cost maintenance of locomotives
First cost.

Safety of Operation

The steam locomotive has been developed by degrees to such a state of perfection that it is common to see it operate at near 80 m. p. h. and with perfect safety; but no one would think of operating at this speed backwards. With the coming of the electric locomotive, the railroad operator is not content with single end operation, but must have a locomotive that will operate equally well in either direction. This does not impose any serious difficulties in the design of locomotives which operate at speeds under 50 m. p. h., but with locomotives for the higher speeds it presents new problems or at least it requires the most careful consideration of the running gear details, to obtain the most satisfactory results as to tracking and the effect on the rails and road bed.

The steam locomotive has what now seem to be natural characteristics to allow high speed operation in one direction. These characteristics are: Low center of gravity at the front end carried on the center pin of a two axle guiding truck, tending to prevent rolling over and having but little effect on the guiding; and high center of gravity on the rear end with inside journal bearings allowing the locomotive to roll and increasing the time element, which thus reduces and distributes the lateral pressure against the rail over a longer distance. This increases the vertical pressure on the rail, thus holding it more firmly in place. These same characteristics can be obtained in electric locomotives by the sacrifice of double end operation.

The advantages gained in operating the electric locomotive in either direction are so important that means should be provided for satisfactory double end operation. One way of doing this is by using a four wheel guiding truck at each end of the locomotive. With the use of the extra truck, however, the importance of a high center of gravity largely disappears. The lateral pressure against the rail at the rear end now appears at the truck flanges rather than at the flanges of the driving wheels and the high center of gravity no longer provides the same increased vertical pressure on the outer rail at the point of the maximum lateral pressure. The lateral stresses from guiding the main frame being taken at the center pin of the two guiding trucks, the additional vertical pressure on the outer rail is dependent upon the height of these center pins rather than upon the height of the center of gravity of the main frame above the wheel hubs, thus leaving less advantage to be derived from a high center of gravity.

To demonstrate more clearly, it is well to see what happens to a locomotive when entering a curve, which is also illustrative of its action on tangent track when oscillating from one side to the other. A locomotive having a high center of gravity and with two driving axles guided by a two-axle swivel truck will serve to illustrate the action. As the locomotive enters the curve, its tendency is to continue on in a straight line but the flange of the leading wheel gradually comes in contact with the outer rail, giving the guiding truck an angular motion about its outer rear wheel and exerting a lateral pressure against the center pin, thus giving the main frame an angular motion around its outer rear wheel.

The lateral pressure tending to displace the rail at the leading wheel is the amount required to slip the two inner wheels, and to accelerate the truck around its outer rear wheel, plus one-half the amount required to slip the two leading drivers and the rear inner driver, and to accelerate the main frame around its rear driving wheel, plus its relative portion of the centrifugal force of the whole locomotive. The lateral pressure tending to displace the outer rail at the rear wheel of the leading truck is the amount of reaction from slipping the two inner wheels and the angular acceleration of the truck plus one-half of the amount required to slip the two leading drivers and the rear inner driver and to accelerate the main frame around its rear outer driving wheel, plus its relative portion of the centrifugal force of the whole locomotive.

The lateral pressure tending to displace the outer rail at the rear wheel of the main frame is the amount of reaction from slipping the two leading drivers, the inner rear driver and the angular acceleration of the main frame plus its relative portion of the centrifugal force of the whole locomotive. The greater weight being concentrated at the drivers, and the distance of the truck center pin from the main truck wheels being greater, and the fact that there is but one wheel to take the strain, it follows that the point of the greatest concentrated lateral pressure is at the rear outer driving wheel.

The above disregards the important factor of time, in the accelerating and centrifugal forces due to the rolling, governed by the height of the center of gravity above the wheel hubs, which tends to reduce the lateral pressure at the rear outer driving wheel. With a high center of gravity above the wheel tread the accelerating and centrifugal forces also tend to tip the locomotive up on the outer driving wheels, relieving the weight from the inner wheels and thus lessening the force required to slip them, at the same time increasing the adhesion between the outer rail and tie by the additional weight. On good road bed and rails the locomotive described is capable of being run at above 80 m. p. h. without any apparent bad effect on the track.

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*A paper which will be presented and discussed at the Railroad Section of the annual meeting of the American Society of Mechanical Engineers, held December 8, 1916, in New York.

If this locomotive is operated in the opposite direction, the lateral stresses at these wheels are of the reverse order, the guiding force now being applied at the driving wheel flanges and the reaction taken through the center pin to the truck wheel flanges. The swivel truck, now trailing, is free to oscillate from one side to the other, and the reaction from the force of turning the main frame may be applied at the center pin when the truck wheel flanges are tight against the inner rail. The force is thus allowed to accelerate the truck as well as the main frame through the gage clearance to the outer rail, thus adding momentum, the value of which depends upon the lateral distance through which the truck is moved. As the vertical pressure on the rail is limited to the normal weight at the wheels plus the vertical component of the force applied only at the height of the center pin of the truck, the relative lateral to the vertical pressure at the wheels of the truck may be greatly increased. A number of observations have appeared to confirm the fact that the action of the trailing truck above described is one of the most important in producing excessive lateral pressures against the rail in a symmetrically built electric locomotive with similar trucks at both ends. It will be seen therefore that while the swivel truck is desirable as a guiding agent at the front end, it is not as desirable at the rear end, and means must be provided to prevent oscillation of the truck and to accomplish the same results as the high center of gravity in a single end locomotive.

To accomplish these results, it is necessary to reduce the momentum effect and to reproduce the equivalent of the time element factor and of the increase of vertical pressure on the outer rail that is characteristic of the high center of gravity single end locomotive.

The momentum effect can be reduced by introducing resistance against swivelling, thus restricting the truck from oscillating from one side of the track to the other, the amount of this resistance to be determined by the allowable amount that can safely be applied to the truck when leading. To reproduce the time element factor, lateral movement can be given to the truck center pin by any of the several methods for giving lateral movement to the leading truck center pins on locomotives. However, the writer has obtained the best results with the method that is the nearest to constant pressure and dead beat, as it also tends to prevent oscillating. To increase the vertical pressure on the outer rail the center bearing of the truck can be made wide, thus allowing the vertical component of the lateral pressure at the center of gravity to be transferred through the bearing to the wheel, or with the narrow center bearing the height may be made such that the lateral pressure at that point will result in an increased vertical component independent of the height of the center of gravity.

Adaptability to Service Conditions

The electric locomotive, besides being required to operate in either direction, is often also required to be adapted for operating high speed passenger trains and heavy low speed freight trains over main line tracks, to negotiate sharp curves, and to be easy on light track and bridge structures. With locomotives having geared motors, the requirement of operating the passenger and freight trains can often be met by changing the gearing to obtain the proper speed and draw bar pull. The running gear can be made with trucks of short wheel base and coupled together, the number of trucks depending upon the required weight of the locomotive for its maximum draw bar pull, and also on the allowable weight per axle. With such a design curves of very short radius can be operated over and the weight per axle can be such as to allow operation over light structures.

It is the writer's opinion that the double end locomotive, while its characteristics are different, can be designed for high speed with safety equal to the single end locomotive, and this regardless of the height of the center of gravity.

Reliability in Service

When the design is such that it is safe to operate at the required speeds and is proper for the curves and other service requirements, and a liberal factor of safety is provided for the parts subjected to strain, the reliability in service affected by the mechanical part of the locomotive depends mainly upon the bearings, their lubrication, and the method of power transmission from the motors to the drivers. It is necessary therefore to provide effective lubrication, in connection with a simple driving mechanism having as few bearings as the design of the motors will allow.

After providing all the safety appliances recommended by the Interstate Commerce Commission, it is important to arrange for the most convenient location of the operator to allow him an unobstructed view of the track and signals, to place within easy reach the air brake valve and locomotive signal device handles, as well as the reverser and power controller handles, keeping in mind the importance of making them so free from complication that the operator will require the least amount of thought to manipulate any of the devices and be free to respond to signals and look out for emergencies.

The arrangement for housing the electrical apparatus and its position in the cab must be governed largely by its design, but it is important to arrange it so that its operating parts are accessible and easy to inspect, and at the same time are protected against persons coming in contact with any live parts.

Power Efficiency

The power efficiency as affected by the mechanical design is governed largely by the type of the traction motors. It is apparent that the gearless motor mounted directly on the axle allows the design of the maximum efficiency on account of its few bearings and its absence of gearing and moving parts. The gearless motor which is mounted on a quill and driving through springs to the wheels may be considered second in its possibilities for high efficiency design, it having additional bearings and a greater number of moving parts. The single reduction geared motor with its additional bearings and gear losses can be given third place in its possibilities for high efficiency design. The single reduction geared motor driving through gears and side rods to the wheels may be placed fourth. The gearless motor driving through side rods and jack shaft to the wheels should be placed fifth.

Service Time Factor

The service time factor is dependent upon the ability of the locomotive to operate under all its service conditions and without undue strains, which requires a liberal design of its wearing parts. In addition to this it depends on the simplicity of its design and the ease with which its parts can be inspected, adjusted, repaired or replaced.

Cost of Maintenance of Permanent Way

The cost of maintenance of the permanent way is a very important item and can be increased or reduced by the design of the locomotive. The lowest cost is obtained when the locomotive meets its service requirements without undue strains, when the rotating parts are balanced, the weights per axle are suitable for the structures, a suitable equalizing system is provided to maintain the proper weight distribution, and when provision is made to protect against flange wear.

Cost of Maintenance of Locomotives

The cost of maintenance of the locomotive is dependent upon its safety of operation, its adaptability to service conditions, its reliability, its convenience of arrangement, and the same items that enter into its service time factor. It is also governed by the same conditions that affect the maintenance of the permanent way. The care with which the material is selected, the quality of workmanship, the ease with which the parts can be inspected, adjusted, repaired or replaced, and the simplicity of the design are the most important features that govern the maintenance cost.

First Cost

The first cost of a locomotive will depend largely upon the design chosen, but its importance, except at the time of purchase, becomes of little moment when taking into consideration the eight foregoing features. With two locomotives designed for the same service the cost of the difference in the efficiency and in the locomotive maintenance alone for one year may when capitalized amount to a sum representing a considerable proportion of the first cost of one of the locomotives.

The writer feels that too much importance cannot be given to developing to the utmost the mechanical parts of the electric locomotive, that are the simplest in design and the highest in efficiency. From the present outlook, the locomotive for high speed passenger service with the gearless motor, its armature being mounted directly on the axle, and the locomotive for freight and switching service with the single reduction geared motor, mounted on and geared to the axle, lend themselves best to simple design and low cost of maintenance.

Interstate Commerce Commission's Hearing on the Headlight Case

A HEARING was held at Washington on October 30 and 31, before the members of the Interstate Commerce Commission to enable the railroads to present additional testimony in connection with the commission's orders requiring locomotives to be equipped with headlights with sufficient intensity to enable a person with normal vision, in the cab of a locomotive, to see a dark object the size of a man at a distance of 1,000 ft., under normal weather conditions. The hearing, which was called to consider testimony regarding a series of tests made on the New York Central just outside of New York on September 28, at once developed into a contest between the representatives of the railroads and the officers of the engineers' and firemen's brotherhoods who challenged the fairness of the test, which they had refused to have anything to do with. After a day and a half of testimony regarding the test, the commission ruled, after a request of the railroad attorneys, that each side be allowed to present twenty witnesses before an examiner and that the evidence need not be confined to the New York test. This gave the railroads the opportunity to put on the witness stand a number of locomotive engineers who testified that the dazzling glare of the electric lights obscured signals and was dangerous. The brotherhood also expected to call as witnesses engineers to testify in favor of the electric light.

At the opening of the hearing B. H. Meyer, chairman of the commission, said that if practicable they wished to confine the witnesses to one representing the carriers, another representing the employees and one called by the commission. A. G. Trumbull, assistant to the mechanical superintendent of the Erie, testified regarding the test for the road; A. G. Pack, assistant chief boiler inspector, was called as a witness by W. S. Carter, president of the Brotherhood of Locomotive Firemen and Engineers, and G. E. Murray, headlight electrician for the Chicago & North Western, was called as a witness for the commission.

New York Central Test.

Mr. Trumbull gave a detailed description of the test, in which steam and electric locomotives were used, equipped with 250-watt, nitrogen-filled electric headlights, furnished by the Pyle-National Company, with 9 by 18-in. reflectors. The headlights were adjusted by a representative of the headlight company. He said that when the locomotive on which he was riding was moving north and rounding a curve, facing three locomotives standing headed south, equipped with electric headlights, the effect was to seriously interfere with his vision; that it was impossible to tell whether any hand signals were being given, and that automatic block signal indications between him and the opposing locomotive were greatly confused. The green light was completely obliterated until within 500 ft., the red light was rendered much less distinct, the yellow light appeared white and he was not able to distinguish the signal correctly until within less than safe stopping distance. He also saw confusing reflections from other signal lenses, was unable to distinguish a flagman at normal distance, and the light from a flagman's lantern was obscured; on one test he missed the flagman entirely. The red marker on a train ahead was also rendered much less distinct. A red marker was mistaken for yellow by several mechanical officers and as the locomotive approached the signal bridge the lights were obscured and he was unable to see any of them for a time. White classification lamps on the locomotive ahead were practically invisible for distances exceeding 200 or 300 ft. In the test to see at what distance objects on the track could be seen, a man dressed in dark blue overalls walked down the track toward the locomotive and the observers in the locomotive indicated when they saw the "object" by blowing a whistle, whereupon the locomotive was stopped and the distance was measured. John McManamy, assistant chief inspector of locomotive boilers, thought he saw the object at a distance of 2,389 ft., but after the distance had been measured he asked for a re-test and saw the man at a distance of 994 ft. A. G. Pack, assistant chief inspector, blew the whistle at a distance of 772 ft., and various railroad mechanical officers blew the whistle at distances ranging from 552 to 764 ft. The eyes of the railroad officers were tested afterwards and they were found to have normal vision according to the standard prescribed for locomotive engineers.

Mr. Trumbull said the tests had confirmed his opinion that for congested suburban territory with multiple tracks and a large number of signals the high power headlight was positively dangerous.

Mr. Carter said that as no representatives of the brotherhood were present at the test he would ask Frank McManamy, chief inspector of locomotive boilers, to cross-examine the witness. Mr. McManamy tried to show that dimmers should have been used; that the tests were not conducted under representative conditions, and that the Erie has some signals which cannot be seen in time to stop within 500 ft. He also asked if fusees were not used as additional safeguards to enable engineers to see flagmen, and showed that the witness had had comparatively little recent experience in riding locomotives at night.

Mr. Pack testified that he had run an engine with an electric headlight for eleven years on the Colorado Springs and Cripple Creek district before becoming connected with the commission, and had never experienced any difficulty due to the headlight. Although he admitted that his road was mostly single track with no block signals, he said he ran into a station facing an electric headlight on the locomotive of another road and could see the order board back of the light as plainly as if it had been an oil headlight. Mr. Pack said that he had never experienced any difficulty with flags or signals, using electric headlights, that he never saw any "Phantom" signals or confusing indications caused by high power lights nor any other conditions that would interfere with safe operation. He regarded the high power headlight as one of the greatest safety devices used on a locomotive. Cross-examined by Mr. Spaulding of the New York Central, concerning the results of the test, he replied that he was having trouble with his eyes that night and that the headlight used did not seem to be giving results up to standard.

Mr. Murray testified in favor of the electric headlights, saying that they had given satisfactory results on the North Western, but that during the test in New York he thought that the lights were not up to standard. Mr. Murray said that the requirement of the commission would relieve his company from observing state laws with even more rigid requirements and in reply to questions by Commissioner Clark he said that he had never known of an accident on his road caused by the headlight of the nitrogen bulb type. Asked whether he thought the proposed rule of the commission was a feasible one for all roads, he said that it would be necessary for each road to study its own conditions and to adopt the type of light most suited to its requirements.

Mr. Spaulding then asked permission to introduce additional witnesses. The brotherhood representatives objected to this. The commission took a short recess and announced that each side might put on 20 witnesses.

On Tuesday afternoon the hearing was resumed before examiners' attorney, E. W. Himes. C. T. McGinnis, special representative of the Pyle-National Company, who had adjusted the light before the New York test, was called as a witness for the railroad. He said that he had left nothing undone to get the best result possible and that the lamp used had been sold from the regular stock, but that they had not given entirely satisfactory results. He said that there was a wide variation in reflectors and lamps and that if it had been possible to try out several lamps and reflectors it would have been possible to match up a lamp and a reflector that would give much better results. He had never had any complaints, but had occasionally found that he could not get the required distance with the light. He said that there are about 40,000 Pyle-National headlights in service.

Additional Testimony.

Several locomotive engineers gave testimony regarding the effect of the high power light in obscuring signals. J. Doherty, road foreman of engines of the Michigan Central, said that he had never run an engine equipped with an electric headlight, but that they had given difficulty when approaching him on parallel roads in Chicago suburban territory and at Michigan City. He said that the views of most of the engineers he had talked to confirmed his objections to the electric headlight. O. P. Keller, an engineer on the Manhattan and Broadway limited trains of the Pennsylvania, also testified against the electric headlight, saying that he would rather have no headlight than the electric blinding light in the eyes which prevents seeing signals or gives false indications.

Altogether nearly a score of engineers running fast passenger trains on roads entering New York City testified that, in their opinion, electric headlights would be a positive menace to safety of operation in their territory because they obscured signals and temporarily blinded engineers who had to face such headlights approaching from the opposite direction. Some of them had had experience with electric headlights on their own engines, others had faced them on electric trolley lines paralleling their own lines, and all of them had been present at tests with electric headlights made on the New York Central recently. In addition, 45 locomotive engineers and 13 road foremen of engines and locomotive inspectors presented to the commission, through counsel for the railroads, a petition that they be allowed to testify, but the commission declined to change the ruling it had previously made limiting the number of witnesses to 20 for the railroads and 20 for the brotherhoods.

Coercion of Witnesses.

Sensational testimony regarding the methods of the Brotherhood of Locomotive Engineers in dealing with its members who disagree with the legislative plans of its officers was presented at the hearing on Thursday, November 2, and following days.

W. H. Rother, an engineer employed on the Cleveland, Cincinnati, Chicago & St. Louis, testified that he had been tried and acquitted by his local division of the brotherhood, No. 492, at Indianapolis, on charges preferred by Grand Chief Engineer Warren S. Stone of violation of the "laws" of the brotherhood in testifying before the Interstate Commerce Commission that he regarded electric headlights as dangerous. After his acquittal, Grand Chief Stone had recalled the charter of Division 492 and organized a new division in its stead, excluding Rother, together with those who had voted for his acquittal, and those who had refused to obey an order to refrain from associating with Rother.

J. T. Heller, another Big Four engineer, testified that he had been expelled from Division 143 of the brotherhood on charges preferred by Stone because of his testimony before the Interstate Commerce Commission.

A. E. Martin, also a Big Four engineer, said that he had been excluded from Division 546 and ostracized by his fellow members for acting as Rother's attorney at his trial, and that the only evidence presented against Rother was a copy of his testimony before the Interstate Commerce Commission.

D. P. Keller, an engineer employed on the Pennsylvania Railroad, testified that he had been tried and acquitted by his local division, No. 74, on charges preferred by order of Grand Chief Stone because he had expressed an opinion unfavorable to electric headlights in the presence of a member of the Pennsylvania legislature, and that he had afterward been expelled on charges preferred by Stone because he had joined the Pennsylvania Mutual Beneficial Association. He also testified that he had sent to the Interstate Commerce Commission a copy of a circular addressed by Mr. Stone to members of the brotherhood, threatening them with expulsion if they interfered with the plans of the brotherhood in connection with headlight legislation.

D. P. Trostle, an engineer on the Philadelphia & Reading, testified that H. E. Wills, legislative representative of the Brotherhood of Locomotive Engineers, and A. G. Pack, assistant chief inspector of locomotive boilers of the Interstate Commerce Commission, had warned him while in the hearing room of the Interstate Commerce Commission on October 30 that he would be violating the laws of the brotherhood if he testified unfavorably to high-power headlights.

These engineers were allowed by the Interstate Commerce Commission to present their testimony only after a vigorous objection by Mr. Stone and W. S. Carter, president of the Brotherhood of Locomotive Firemen and Enginemen, and after the hearing had been interrupted for a day while the commission deliberated over a statement filed by counsel for the railroads, outlining the character of the evidence they proposed to introduce. After the testimony had been allowed, Mr. Stone admitted the principal facts alleged and identified copies of letters which he had written bearing on the cases.

The Brotherhood "Law."

The sections of the "Constitution and Statutes" of the Brotherhood of Locomotive Engineers under which members have been expelled for giving testimony before the Interstate Commerce Commission are given herewith:

"Members Interfering with Board—Penalty."

"Sec. 11. Any member or Division refusing to sustain the official acts or instructions of the Legislative Board, or who circulates or signs any petition, or who, by verbal or written communication to railroad officials or others, calculated to injure or interfere with legislative matters offered by the Legislative Board or at any time makes suggestions to railroad officials or to state legislators that may be detrimental to the interests of the B. of L. E., or any train service organization, shall be expelled, when proven guilty, as per Sec. 49 of the Statutes."

"Interfering with National Legislative Matters."

"Sec. 12. Any member or Division who, by verbal or written communication to anyone calculated to injure or interfere with national legislative matters, offered by our Legislative Representative at Washington or Mexico, or at any time makes suggestions to anyone that may be detrimental to the interests of such legislation, shall be expelled, when proven guilty, as per Sec. 49 of the Statutes."

When the hearing was resumed on Friday evening, Examiner Hines announced that the commission had concluded that while it is not interested in the rules and regulations of private organizations, in order to properly weigh the evidence, "it is interested in being advised with respect to deterrent influence brought to bear upon witnesses." It, therefore, denied the motion to strike out the testimony.

The brotherhoods completed their case Tuesday afternoon without giving any rebuttal testimony to the charges of intimidation and coercion. Oral arguments will be heard in Washington on November 27.

According to the latest ruling of the commission, the headlight order is to take effect on Jan. 1, 1917.

Railway Extension in Chile.—Permission to construct a branch line from the Antofagasta-Bolivia railway, uniting the station Salinas with the nitrate deposits, Los Penitentes and Carabana, has been granted to Emilio A. Carrasco. The government has also granted to Alfredo Aldunate and Felix von J. Marteville permission to construct and exploit an electric railway between La Union, Rio Bueno, and Filuco, and a branch line from Rio Bueno to Lago Rauco.

The English Channel Tunnel.—An advocate of the English Channel tunnel recently gave some figures as to the cost and possible earning capacity of the tunnel. The estimated cost of construction is $80,000,000. It is calculated that of the 2,000,000 passengers who crossed the channel in both directions during the year, at least 65 per cent, or say 1,300,000, would use the tunnel, and if each were charged 10s. ($2.40) this would amount to an income of $3,120,000 a year. To this it was hoped to add $325,000 for baggage, $200,000 for postal services and $4,000,000 for freight traffic, the total estimated revenue being, therefore, $7,645,000. Running expenses were put down at $2,000,000 per annum, which would leave $5,645,000 as the annual net earnings on the $80,000,00 or over 7 per cent.

Railway Electrical Engineers' Convention

The Ninth Annual Convention Held at Chicago Was Marked by Record Attendance and Excellent Reports

THE ninth annual convention of the Association of Railway Electrical Engineers was held at the La Salle Hotel, Chicago, October 31 to November 3, inclusive. E. W. Jansen, electrical engineer of the Illinois Central, presided. The attendance at the convention this year was exceptionally good, with 118 railroad men present; 85 were senior members, 20 junior members and 13 guests. The Railway Supply Manufacturers' Association reports a registration of 112, 48 of whom were representative members. The first meeting was called to order at 10 o'clock Tuesday morning, October 31 and after hearing the president's address and the report of the secretary and treasurer, the attention of the meeting was turned to the consideration of new business.

Classification of Technical Literature

Under the head of new business, J. R. Sloan of the Pennsylvania, who is the association's delegate on the "Joint Committee on Classification of Technical Literature," presented a progress report of the joint committee. The work of this joint committee is the result of an elaborate system which was presented by the late D. S. Knauss of Philadelphia at the annual meeting of the American Gas Institute in October, 1914, for the classification of literature and data regarding this industry. At that time, after much favorable discussion, the subject was referred to a committee which realizing the demand for a similar classification system in other lines of engineering and realizing the close inter-relation of the various branches of engineering, decided that before putting further work into a system designed for gas engineers alone they would endeavor to get joint action on the part of all kinds of engineers to the end that a satisfactory system of classifying engineering knowledge in general might be devised which would receive the approval of all national engineering societies.

In response to an invitation issued by the American Gas Institute committee to a limited number of representative societies, seven delegates were appointed and met in the United Engineering Societies building in 1915. After a full discussion of the subject the following resolutions were unanimously adopted: "Resolved, that it is the opinion of this committee that it should in conjunction with representatives of other technical bodies undertake the preparation of a classification of applied science." And at a second meeting attended by delegates from 32 technical bodies, and held in New York on May 21, 1915, the discussion fully confirmed the opinion expressed at the first meeting that there was an insistent demand for a satisfactory classification system suitable for the use of engineers and practical men. At this time a formal organization was effected and the name Joint Committee on Classification of Technical Literature was adopted. The committee is now made up of 32 delegates from all the technical bodies in this country and is going ahead with the work of devising a standard system for the satisfactory classification of technical information. At a meeting in New York on April 1, 1916, the executive committee of the joint committee has recommended that certain subjects be assigned to the different organizations most vitally interested in them, the final compilation to be performed by one central body under the supervision of an expert classifier and this is the way in which the work will undoubtedly be handled.

DISCUSSION

J. R. Sloan (Pennsylvania): There has been no subject as yet assigned to the Association of Railway Electrical Engineers. I have also received word that the work of the committee will be taken up by a paid assistant with stenographic help, whose entire salary will be paid by the United Engineering Library.

The report was accepted as a progress report.

Constitutional Amendments

All amendments to the constitution of the Association of Railway Electrical Engineers which had to do with membership were unanimously voted down, so that the wording of the constitution in this respect has not been changed. The same is true for amendment to the constitution regarding admission and expulsion of members and dues. Section 3, under Article 6 referring to management was also left unchanged, as was Article 10, in regard to proposed amendment to the constitution.

The only change to the constitution that met with the approval of the association was Section 2 of Article 5 in regard to election of officers. As amended this section reads: "The officers of the association, with the exception of the secretary-treasurer, shall be elected from the senior active members by separate ballot, without nomination at each annual meeting. Two tellers shall be appointed by the president to conduct the election and report the results. A majority of all votes cast shall be necessary to elect. Election must proceed without adjournment or interruption of other business. Section 3: The term of office of each officer, except the secretary-treasurer, shall begin at the close of the election and shall continue for one year, or until their successors shall be elected and qualified. One vice-president shall be elected from the eastern section and the other vice-president from the western section as hereinafter defined. The secretary-treasurer shall be appointed by a majority vote of the executive committee and shall be continued in office until his office shall become vacant as described in Section 6 of Article 5." The changes in the sections outlined above simply mean that the secretary-treasurer, instead of being elected by the association, will be appointed by the executive committee. This change received the unanimous approval of the members present.

E. W. Jansen, President

Industrial Trucks

J. A. Andreucetti, Chicago & North Western, advised the association that the Committee on Industrial Trucks presented a final report at the last annual convention in 1915, which in substance stated that the Society of Automobile Engineers had practically accepted the recommendations that were sent out by this association by letter ballot, standardizing on sizes of tires and other dimensions. He said that nothing new has developed since that time to require further report, which is also the opinion of Mr. Buckwalter, who had written to Mr. Andreucetti in regard to the matter.

DISCUSSION

L. F. Billau (Baltimore & Ohio): Have any of the members present had any experience with industrial electric trucks in railroad service, using the 24-volt system, as recommended by the association? We have gone into the use of the truck to some extent in our shop and find there is some opposition on the part of certain motor manufacturers against the 24-volt motor, they claiming that the higher voltage motors are more efficient and more economical to manufacture. Only a few manufacturers are on their own initiative offering the 24-volt motor.

President Jansen: Three or four years ago we tried out a certain make of industrial truck, using a 48-volt motor and found considerable leakage across the battery cells. The construction of the battery was such that even when standing there were leaks and slight sparks. As the truck was used where cotton was stored, the underwriters practically ruled the truck off the dock. For that reason I personally prefer the 24-volt motor, with as few cells and as few connectors as possible. We have had six different makes of trucks in our tests and five of them had low voltage motors.

L. F. Billau (B. & O.): The trouble with the 24 volt-motor seems to be due to abnormal grade conditions. It has been our experience that some of the low voltage motors have been unable to negotiate grades up to 16 or 17 per cent. The manufacturers of these motors emphasize the difficulty of furnishing commercially a low voltage motor that would take an abnormal over-load.

J. L. Minick (Pennsylvania): In my opinion the trouble is simply one of design. For instance, a Buckwalter truck was not intended to negotiate grades greater than 10 per cent under actual service conditions, consequently when going up a 15 or 17 per cent grade it will lay down on the job. On the other hand, the 48-volt motor may have been designed for that specific duty.

W. A. Hancock (C. of G.): We use quite a number of industrial trucks for terminal business, around the cotton mills and also for hauling fertilizers. We use 24-volt motors and do not have any difficulty in overcoming 10 or 12 per cent grades with them. Our trucks, which are of the straight frame, drop frame and regular freight types, are giving good service.

E. S. M. Macnab (C. P. R.): I think the 24-volt truck is preferable to the 48-volt truck or any other higher voltage. For one reason 24 volts is practically the same voltage used in passenger cars at the present time. Therefore, the 24-volt trucks, which are used in car yards, can be charged on the same line with the electric car lighting equipment. Another good reason for using the 24-volt trucks is that the number of battery cells is materially reduced, which reduces the number of connections. At one point on the Canadian Pacific we have had difficulty in ascending the grade up to the ships when loading on a gang-plank, but the trouble was overcome by a reduction of gears, in other words, a reduction of speed and not by a change in voltage.

L. F. Billau (B. & O.): Personally, I am in favor of the 24-volt trucks for reasons mentioned and also from the point of view of maintenance and I feel that if we are having trouble in getting a satisfactory 24-volt motor, that it is simply a question of design. It is up to the motor manufacturer to give us a satisfactory motor.

Electric Headlights

The Committee on Locomotive Headlights had not prepared a formal report this year due to the unsettled condition of legislation affecting this subject. The chairman presented a verbal report of progress during the year.

The committee is as follows: J. L. Minick, Pennsylvania, chairman; Charles R. Sugg, Atlantic Coast Line;

J. J. Hack, Southern Pacific; E. W. Jansen, Illinois Central; H. R. Pennington, Chicago, Rock Island & Pacific.

Discussion

E. S. M. Macnab (Can. Pac.)—What has been done with regard to changing the arc headlight to incandescent and has the gas-filled lamp altered the situation?

J. L. Minick (Penn.): A number of roads are now changing from arc lamps to incandescent lamps; I see no reason why that change should not be made, usually with a considerable saving in wattage consumption. A line of incandescent lamps has been developed for locomotive headlight work either in a 6-volt or a 30-volt type and there should be no reason why they cannot be successfully applied to the equipment already in service.

C. R. Sugg (A. C. L.): We have at present 210 incandescent headlights all equipped with 250-watt 32-volt lamps. We adopted the following procedure when ordering these headlights: We obtained three incandescent headlight equipments from manufacturers and put them on three locomotives. We then let three men have them for a while, after which we took them away from these men and gave them to somebody else. This started a fight. The men who first had the lamps wanted them back, but they were told if they desired that type of electric headlight they would have to make a written request for one. As a result, out of the 210 that we have now, about 175 were installed by special request of the engineers; in fact, it is now our practice to refuse to install them except by such special request. Every one of the locomotive engineers who have operated with the incandescent headlights says that he would not have the old electric arc lamp back under any consideration. Incandescent lamps that we now have are mostly on one division and the arc lamps on another. Where we have installed the incandescent lamps we have reduced the headlight failures considerably and I know that the maintenance cost is much less than for the arc lamps on account of the trouble we formerly had from burnt out armatures.

J. A. Andreucetti (C. & N. W.): The North Western road has today approximately 1,500 locomotives with incandescent headlights, using 19 by 9 in. reflectors.

President Jansen: On some tests recently made by the Pennsylvania Lines West using a standard 18 in. by 9 in. reflector with a 250-Watt 32-volt lamp, about six regular locomotive engineers were used as observers. These men had their eyes examined just before the test and at a speed of 20 miles an hour dropped a small sand bag when they first saw the object, nobody knowing at what point the object would show up. The average of all readings was a little over 800 ft. on the running test, but during the standing test the average of all observers was a little over 1,000 ft. The law specifies that the object must be seen at a distance of 1,000 ft., but it does not specify whether the locomotive should be running or standing still.

J. R. Sloan (Penn.): Is the order as issued in such shape that it can be understood; does a railroad know what is required of it and if not what are the points that are undetermined?

J. L. Minick (Penn.): From railroad men who are interested in this subject, I gather that the objection to the Interstate Commerce Commission ruling is the indefiniteness of the order. It specifies that engineman with normal eyesight shall be able, under normal weather conditions, to see an object the size and shape of a man dressed in dark clothing at a distance of 1,000 ft. There is not a single thing in that specification except the distance of 1,000 ft. that is definite. There is no normal eyesight; there are no normal weather conditions and a man dressed in dark clothing is also an indefinite description. What kind of a man, how big a man, how small a man? Is he tall or short, wide or narrow, white or black What is dark clothing? I have put that question by letter to half a dozen of the big tailors in the United States and I have gotten just as many different answers; each one has his opinion as to what dark clothing is. My own impression is that the thing the railroads would like to bring about is some kind of a specification that is definite in its terms and which can be measured and reproduced tomorrow as well as any other time. The suggestion of the railroads has always been to go to terms of candle power. Candle power can be measured exactly, the same as voltage, steam pressure, gallons of water or any other measurable quantity. If that point can be agreed upon, the only remaining thing is to have someone in authority, determine how much candle power.

C. J. Causland, 1st. Vice-Pres.

Car Lighting Handbook

The progress report of this committee appeared in the October issue. After reading the report, E. Wanamaker, chairman of the committee, said that in the face of the preponderance of electricians over engineers in the association, it is only fair that the electricians receive a great deal of consideration by the association. The best way that that can be done is to get up a handbook which is not a book or work on engineering, and which covers only the vital points in which the electrician is especially interested. At present any book that such an electrician buys is so written that he has to read 90 pages that do not do him any good to find 10 pages of real information. For this reason, it is my idea that the association is well able to get up such a handbook on electric car lighting. If the handbook is successful for car lighting, a similar one could be prepared on electric headlights, shop equipment, turntables, coal chutes, pumping plants and other special phases of work handled by electricians on steam railroads.

J. R. Sloan (Pennsylvania): The material for the proposed handbook is just the kind of data that we should have in the loose-leaf proposition that I have been working on and I think that is the form and shape the matter should take, so that it can be placed in the hands of all the members. I furthermore think, that when this matter is brought up finally, it should be printed and copies of it sent to the ranking senior active members on each railroad for criticisms and suggestions before it is finally presented at the convention.

L. F. Billau (B. & O.): I do not know of anything that could be of more practical value and benefit to the electrical men on the railroads than something along the line of a practical handbook such as has been suggested. It could well be used by men in the field as well as men in the office and it is something which railroad men have lacked, but have long needed.

J. J. Hack (So. Pac.): I am very much in favor of a book of this kind. We are all changing men frequently and lots of them go on the job and do the best they can, but for lack of information they often do the wrong thing.

J. E. Gardner, 2nd Vice-Pres.

J. Andreucetti (C. & N. W.): The committee has already gathered quite a comprehensive set of working rules and instructions to be incorporated in the handbook, so that the work of the committee is well under way and should be ready to be presented to the association for approval next year.

The report was accepted as a progress report.

Illumination

The complete report of the Committee on Illumination was printed in the October issue of the *Railway Electrical Engineer.*

DISCUSSION

J. A. Andreucetti (C. & N. W.): What has been done in relation to the joint conference with the American Railway Engineering Association relative to the future laying out of yards for taking care of the pole lines necessary for the illuminating system?

L. S. Billau (B. & O.): This information is now practically completed and with such supplementary data as we may be able to secure on lighting units will no doubt be of considerable assistance to the American Railway Engineering Association committee.

C. G. Winslow (Mich. Central): Has anything been considered along the line of providing light for signals, thus making the illumination of the semaphore sufficient to entirely do away with the signal light? There is a possibility of adding considerable value to the general yard lighting and at the same time saving the extra cost of signal lighting. In my opinion one pole-mounted light might replace three or four signals.

L. S. Billau (B. & O.): I do not know of any case where a railroad has illuminated the signal semaphore as suggested by Mr. Winslow. The committee did not consider that phase of the question.

W. J. Davis (Am. Lighting Co.): By placing a battery of flood lighting units at each end of the yard at a minimum height of 75 ft. and mounting them so that the beam of light would be as nearly horizontal as possible, a real flood of light would be thrown out over the yard which would give a soft, even illumination. We have found that the 1,000-watt and 750-watt lamps in the flood lighting units are satisfactory. Flood lighting, if properly installed, provides an efficient and economical system of lighting yards; it does away with the overhead system, with conduit, with poles and with excessive lamp renewals. The present systems are good, but I seriously believe that flood lighting, intelligently applied, can do the yard lighting as well, if not better, than anything previousy tried.

J. L. Minick (Penn.): The lighting of ladder tracks in a strictly classification yard becomes a matter of spot lighting each individual switch. For that reason I do not believe, from my experience, that the flood lighting unit will serve satisfactorily with that particular class of yard lighting. There are many other classes of yard service, however, where the use of a flood lighting unit would undoubtedly prove satisfactory.

G. W. Bebout (C. & O.): How about the comparative cost of flood lighting and the series lighting system installed on steel and wooden poles?

J. L. Minick (Penn.): In a yard at Pittsburgh, high voltage mercury-vapor lamps are installed on six 90-ft. towers. I have been told by the engineer in charge that the cost of installation runs over twice as high as the cost of the ordinary magnetite arc installation on poles and that its operating expense is also higher. One objection to the installation of towers in any yard is the fact that the layout of the yard is constantly being changed and for that reason it is highly desirable that a cheap pole construction be used which can be moved back and forth with the growth of the yard. The use of heavy steel towers is also objectionable in many cases because of the heavy permanent foundations necessary and the first cost of the towers.

J. E. Gardner (C. B. & Q.): I have no absolute figures on the saving effected by lighting classification yards, but I have been investigating hump yard lighting during the past month. I have been riding with hump riders in yards which are adequately illuminated to see just where the lights are needed and what these men would do if they did not have the lights. From this investigation I feel that the lighting of the hump in particular, not necessarily the whole classification yard, is vitally important and I do not see how it would be possible to operate a hump with any degree of safety or efficiency if the men had to work without some kind of illumination.

J. L. Minick (Pennsylvania): In regard to the rating of train lighting lamps, I wish to call attention to the two proposed schedules, it being understood that they are purely proposed schedules. We do not know when it will be possible for the manufacturers to come to the figure that we have suggested. We do know, however, that at the present time, the 120-watt gas filled lamp is being used. The manufacturers are working on these lamps and have produced some in an experimental way, which have given fairly good results in some cases, while in others the experimental lamps have given poor results. In general, however, the progress of the art is encouraging. The present plan of procedure is as follows: When one lamp is developed, for instance, in the 30-volt schedule the corresponding lamp in the 65-volt schedule will immediately be shifted to the lumen value which we have specified regardless whether it is a gas filled lamp or whether it is a vacuum type of lamp, the object is, for instance, that if it is possible to produce a 40-watt gas filled 500 lumen lamp in a 30-volt schedule, it will be a simple matter to shift the corresponding size in the 60-volt lamp to the 500 lumen value even though it be a vacuum type of lamp. There is practically no demand at the present time for the 75 or 80 watt lamp consequently the manufacturers are not going to list it in their data book, but will hold themselves ready to furnish such a lamp on request.

Anti-Friction Bearings for Motor Equipment

The report of this committee appeared in the October issue.

Discussion

C. J. Causland (Pennsylvania.): In addition to the report many interesting questions have been considered by the committee one of which was a standard type of railroad shop motor and specifications for such a motor. In answer to a question if any definite information had come from the Power Club as to acts they have taken, Mr. Causland answered that no definite action had been taken at the present time, but that the matter was well in hand. J. A. Andreucetti advised that the Power Club has a committee which is to act in conjunction with the association committee on this subject. Mr. Causland then advised that at a preliminary meeting in March the committee met with 43 motor manufacturers in this country and out of the 43, 32 manufacturers were in favor of anti-friction bearings, the remainder of the manufacturers referred the question to the Power Club. Mr. Causland said that he believed that the association would receive the hearty co-operation of the Power Club in the matter of standardizing on anti-friction bearings for motors.

E. Wanamaker (C. R. I. & P.): While in Schenectady recently I got in touch with the General Electric Company, who advised that they are making an effort to begin the use of ball bearings in their motors, but that their progress at this time is determined by the action of the ball bearing manufacturers. Within the last six months my road has purchased a number of motors for which we specified anti-friction bearings. We had the courage of our convictions on that particular type of equipment as to what the bearings should be and after conferring with the motor manufacturers and the ball bearing manufacturers we went ahead and got the bearings. In case this committee is continued, as it should be, we might be able to furnish some actual data on how the anti-friction bearings on the equipment just mentioned perform in actual service. In my opinion we will have to have considerable data of that nature before the Power Club or any other club can come out and take any real definite action on the proposition. Mr. Gildener of the S K F company suggested that the committee investigate the use of ball bearings on mining locomotives. He also called attention to the table in the Data and Information Committee's report showing that out of a total of 5,417 ball bearing axle generators, there were 40 failures, but out of 2,909 sleeve bearing generators there were 129 failures.

Data and Information

The complete report of this committee was published in the October issue. The discussion is as follows:

Discussion

E. S. M. Macnab (Can. Pac.): The question of electric car lighting cost as shown in this report is interesting, but I would like to draw attention to some of the figures, which vary from $3.88 per car per month up to $26.20 per car per month. I would suggest a sub-committee of the Committee of Data and Information be appointed to investigate car lighting costs and go into the question thoroughly showing how the costs on the various railroads are compiled.

President Jansen: When a road reports that it lights its cars for $6 per month it is evident that there are some items that are not included. The labor would amount to more than that. Another road gives $3.88 as the cost per car per month, which in my opinion would not cover the cost of belts alone not considering battery renewals, lamps, generator repairs or labor.

J. J. Hack (So. Pac.)—The only way to arrive at the cost of operation of electric lighted cars is to take an average over a period of five or seven years.

President Jansen.—Some roads with about 1,000 cars operate them for about $12 a car month, others $11; other railroads find that the cost of operating and taking care of electrical equipment on their cars amounts to $20 per month per car. I think up to the present time if every road included all costs over a period of years, the cost per car month on account of electric lighting would be around $20. I know the Pullman Company charges $30.

J. R. Sloan (Penn.)—I fully agree with Mr. Hack that the cost ought to be figured over a period of years. Up to about four years ago our accumulated average was $49.98 per car month, but after remodeling our equipment our accumulated average to date is something like $24 per car month, which includes all the high costs of the previous years and also includes the cost of remodeling and changing from sleeve bearings to ball bearings.

J. J. Hack (So. Pac.)—I feel that with a general run of equipment, part new and part old, if I can average $18 or $20 per car per month over a term of years, I am doing pretty good.

Alex. Voigt (A. T. & S. F.)—I do not think it is a hard job to get all the car lighting cost in the records if they are handled right. On the Santa Fe nobody but car lighting men handle car lighting material and the entire labor is charged over aganst the car lighting work. We have a shop order covering repairs to cars, undergoing shop repairs. Any other work such as carpenter work or blacksmith work is charged to this car lighting job. We first ascertain the rates for the men from the payroll and charge any outside labor. In regard to the material we have the report from the storekeeper which we in turn check against our daily report; in that manner we have a double check. All bills made by the Pullman Company or other companies against us for labor on our cars on foreign roads pass through our office, the amount of the bill is listed and it is included in the regular car lighting cost. Any work done on foreign cars that we bill for is also credited against our car lighting cost. Our form is practically the same as outlined by the association's committee, of which the late Mr. Frost was chairman, and we have been following that form since about 1902. I cannot think of an item affecting the cost of our car lighting equipment that we leave out, we include the charge for car lighting current, charging it out at a rate that it cost us to produce it or at a rate for which we buy it, and we also go into the details such as hard rubber jars, lamp renewals, and what it is costing us to keep up our ball bearings, etc. On our belt mileage we have our individual record for each car, the total number of the belts are charged, and, knowing the total mileage made by the car, we readily get the mileage per belt.

President Jansen.—On the Illinois Central there is no electrical material of any kind used on the system, belts or anything else but what we know about it. All electricians are on our payroll and their entire time is charged to the cars and all of material they use is shown on the daily reports. We get all the bills for electrical material in our office, we price every bit of material reported, even if it is a screw that goes on the car, and there is no material charged against our cars but what we apply it, no matter whether it is a bolt, suspension parts or wire, or anything electrical or pertaining to electrical work. In that way every bit of material is considered and all the labor—we figure the entire payroll—is charged outright. In this way the amount of material is right and the price is right. If we have any repair work done outside the bill comes to our department and the rest of it goes on the material report, so that everything is included. If a cost record is kept on the basis above outlined on a road where good service is maintained the cost per car month is sure to be between $15 and $20 per car month.

J. A. Andreucetti, Sec.-Treas.

J. R. Sloan (Pennsylvania.)—I do not see any reason why, on a well regulated road, there should be any difficulty in following the form outlined. There is one question, however, with respect to the account which will vary greatly on various roads according to the organization, and that is the overhead expense. With us the overhead is divided into direct and indirect supervision, direct and indirect clerical labor, storehouse expense and terminal expense. Direct supervision is the time of the foreman and assistant foreman. Indirect supervision is the time of the foreman, to whom the car lighting foremen report, prorated among the general foremen and the entire payroll. In addition there is a charge for light, heat, water, etc., in these buildings and another charge added on for the maintenance of the buildings. There is the direct clerical labor for the car lighting foremen's clerks and indirect clerical labor for the general foremen's clerks prorated the same way. Then there is the storehouse expense, which is the expense of the labor of the storehouse keeper and his clerks which is prorated for that month. To the direct terminal expense are charged small tools, repairs for small tools, etc. I know on some roads there is no such thing as indirect supervision, indirect clerical labor, etc., and there is practically no storehouse expense. With us that item averages about 22 per cent of our operating costs.

E. Wanamaker (Rock Island).—We charge our accounts very much the same as Mr. Sloan has outlined. The store department charges us for all the material that is chargeable to electrical work on the cars plus 15 per cent. In regard to the shop orders it is a difficult matter to be sure that the electricians make out their charges correctly. The overhead charges are a large percentage of the total operating and maintenance charge and we absorb every bit of it. In an investigation, during which we tried to find out how much it cost us to light the different classes of cars per thousand car miles per month with gas and electricity, I could not find any figures that were reliable, but I did find that we were paying for things I never knew had to be paid for before.

Loose-Leaf Binders

J. R. Sloan, of the Pennsylvania, verbally presented the following progress report. Your committee on Data and Information for Loose-Leaf Binders has worked through the proceedings and has a large part of the data in shape to send to the printer, but took no action in this respect, as it was known that various items would probably be amended at this convention. The question of purchasing the loose-leaf binders to hold the above data was taken up with the executive committee, but your committee failed to obtain the approval for the scheme of purchasing these binders. We expect to take this matter up again with the executive committee and work up some scheme with them which will meet with their approval. The report of the committee was accepted as a progress report.

Wireless Telephone and Telegraph

In the absence of Dr. Millener, the report was presented by J. H. Wickman, of the Illinois Central. In March, 1916, Mr. Mohler, then president of the Union Pacific Railroad, requested Dr. Millener to actively continue his experiments on wireless telephone and telegraph as applied to moving trains. As a result an old dining car was converted into a wireless laboratory and a receiving and sending station was erected at Grand Island. The station was of 1 k.w. capacity and easily exchanged messages with Omaha and surrounding towns. It was contained in two trunks built after the style of the United States Army, one for sending and one for receiving. The wave length of these stations was 800 meters and the tone wheel was so arranged that a different tone would indicate the different stations called, so that it would be unnecessary to continue calling the station, this being done by merely holding the key down. By July 31, 1916, the car was ready and the first trip was made. On this trip no messages were received because of some loose connections which had been improperly soldered as we found later, although messages from the car were received at one of the other stations. A few days later Dr. Millener was informed that the experiments would be temporarily discontinued.

DISCUSSION.

President Jansen.—Apparently this work has been discontinued. The Union Pacific has changed management, so that the committee will probably not be continued for the next year. Dr. Millener has made a considerable study of this subject, and I am sure he will be glad to furnish any of our members with information in regard to the use of wireless telephone and telegraph on trains on request.

Crane, Turntable and Transfer Table Motors

The committee report on this subject, which was published complete in the October issue, was presented by Chairman H. C. Meloy, of the Lake Shore & Michigan Southern, and was accepted as a progress report. Mr. Meloy advised that the committee was unable to hold a joint meeting with the Power Club Committee, but that Charles Robbins, chairman of that committee, had submitted a report just a few days previous to the convention. Following is Mr. Robbins' letter submitting his report:

Mr. H. C. Meloy, Chairman.

The Committee appointed by the Electric Power Club to confer with your Committee on the above subject submit herewith a report which partially covers the situation from the point of view of the motor manufacturer in that it presents considerable data concerning ratings, speeds and dimensions.

The Committee has also conferred with the crane builders and has partial data on this subject, which is submitted to you together with the report on the motor situation.

Our Committee feel that the situation is so large that further co-operation should be carried on between your Committee, that of the Electric Power Club, crane builders, and the iron and steel electrical engineers, and would respectfully suggest that your association take action toward the continuance of the study of this subject.

Signed by: W. L. Merrill, H. C. McCutcheon, Charles Robbins, Chairman.

Compressed Air

The complete report on this subject was published in the October issue.

Discussion.

There was some discussion as to the correctness of the statement that the leakage through an orifice is constant when the pressure is more than twice the outside pressure, but J. E. Gardner (C. B. & Q.) pointed out that the statement was based on Pierces' formula for the flow of gas through an orifice, and although it deals with various velocities, its application in this case is justifiable as only a rough approximation was desired.

Electric Welding

This report (October issue) was presented by J. H. Bryan of the *Railway Electrical Engineer*.

Discussion.

J. H. Bryan.—Referring to the curve in Fig. 2, it will be noticed that the comparison is based on equal amounts of heat. In that curve no allowance is made for standby losses, so in reality the cost figures are more favorable to arc welding than is indicated. Referring to the other figures you will notice that the curve for cutting steel by gas only runs to about six inches, while the curve for cutting by the arc is continued up to twelve inches, and can, as a matter of fact, go still further, if necessary.

J. H. Edwards (C. R. I. & P.)—I would like to have some more information regarding the slag covered electrode when used as a positive, as mentioned on page 503 (October issue).

J. H. Bryan.—It is my understanding that reference is made to a special coated electrode on the market in this country. It has a slag of asbestos which tapers around the electrode itself. The asbestos and clay with which the asbestos is impregnated melts down and forms a glazed covering over the work which protects it from oxidation. This slag is of such a nature that the metal is kept absolutely clean and bright and no darkening of the metal surface results. When using this electrode it can be used as a positive, but for ordinary work, on fairly heavy sections, it is better to use the electrode as a negative because the excess heat of the positive can be used to better advantage on the work than in the electrode.

Robert Kinkead (Lincoln Elec. Co.)—I wish to bring out the importance of using a sand blast when welding flue sheets, and it is my understanding that some of the larger systems have installed sand blasting equipment for that purpose with very satisfactory results. Two roads that have such equipment are the Pennsylvania and the Baltimore & Ohio.

D. J. Cartwright (Lehigh Valley).—When we first started flue welding we used ordinary wire brushes, but we have since installed a sand blasting apparatus, and, in my opinion, the work done when using the sand blast method of cleaning is very much better than could be done with the old method. I should say that we save about 25 per cent in time in welding a flue when the sand blast is used.

Robert Kinkead (L. E. C.)—I find that the use of what is commonly known as flux in electric welding has been practically abandoned.

J. H. Edwards (C. R. I. & P.)—I agree with Mr. Kinkead in this respect.

J. H. Bryan.—In regard to the standardization of welding operations: It is important that this sort of work be followed carefully, otherwise the process is likely to be brought into disrepute. In one railroad shop, not long ago, flue welding was done on a piecework basis, and the men were turning out flues at an amazing rate, about 40 an hour, which rate, to those who are familiar with electric welding, is unreasonably high and inconsistent with good welding. In the same shop they are now welding about 12 or 15 flues an hour, which is more in line with correct practice, and the results they are getting since has fully justified the extra money spent on that particular job. It is difficult to inspect welding jobs of any sort and say from the appearance of the finished work whether or not the welds are perfect or whether or not simply a bunch of metal has been thrown in. It is a case of depending absolutely on the reliability of the man himself as to the results, and when a man is found who can do reliable and accurate work, he should be given a rate which will give him plenty of time to do the job without skimping. For this reason piecework rates should be followed very carefully, and it requires a man who is thoroughly experienced in welding to make final decision in these matters. I wish to also point out that the carbon electrode could well be used more than it is in railroad shop practice for building up processes and for cutting away and cleaning, preparatory to using the metal electrode. Usually carbon electrode work can be done at a lower cost for labor and current than with the metal electrode on account of the greater speed with which the work can be turned out. Mr. Bryan also spoke of the advisability of each railroad having at its various large terminals a portable electric welding outfit consisting of a gasolene engine driven generator, mounted on a car propelled by the same gasolene engine.

The report of the committee was accepted as a progress report.

Maintenance and Repairs

The report of this committee, as published in the October issue, was read by J. R. Sloan.

DISCUSSION.

Mr. Seabolt (C. & O.).—Under the heading of distribution the report states that "conduit in a roundhouse if painted will last approximately ten years." My experience has been that some conduit will not last over two years; as a result we have discontinued using conduit in the roundhouse but are using slow burning weather-proof wire instead.

A. J. Farrelly (C. & N. W.).—The life of conduit depends on where it is placed. We have found on the North Western that some conduit has lasted for 15 years, while in other cases it has not lasted more than three years. We find that where the conduit in a roundhouse is placed below the gas line, little trouble will result whether the conduit is painted or not.

J. R. Sloan (Penn.).—I wish to call attention to the statement in the first column on page 509, (October issue) about the fifth paragraph, which states that the cost of maintenance and repairs for the individual motor drive installation is from 75 to 100 per cent. cheaper. I think what is probably meant is that the cost of maintenance of a group driven installation is 75 to 100 per cent. more expensive.

J. H. Wickman (Illinois Cent.).—I agree with Mr. Sloan and the statement should be changed as he suggests.

E. Wanamaker (C. R. I. & P.).—In regard to the comparative cost of operating turntables with air and with electricity, will say that the Rock Island used to drive all of their turntables with air tractors. On investigating, however, we found it cost more to run such tractors than it does to buy them, so we discontinued buying any more new ones, going to the motor driven tractors instead. We find that we can operate our motor driven tractor for 60 per cent. of what it formerly cost us to operate with air tractors. We also find that the electric tractors are far more reliable and less likely to be out of commission.

W. L. Bliss (U. S. L. & H. Corp.).—In regard to the supporting of conduits when laid against concrete I will also say that it is a common nuisance on ships to have the cold deck beams collect moisture and drip as well as the pipe in which cold water circulates. It is a common practice on such ships to paint ironwork that has that kind of trouble with paint in which cork dust is mixed. Pipes painted in this way will absolutely not sweat and will remain perfectly dry.

Train Lighting Equipment and Practice

The complete report of this committee was published in the October issue.

DISCUSSION.

J. D. Cartwright (Lehigh Valley), chairman of the committee.—Since the writing of this report the Master Car Builders' Association has voted on the recommendations submitted to them by this association and have accepted every recommendation that was made except one, which was in regard to the fuse block. We would like to re-submit this recommendation and desire that the association go on record as being favorable to this type of fuse block. The Master Car Builders' Association approved the box to hold the fuse but rejected the fuse block.

J. R. Sloan (Penn.).—Referring to Figs. 16, 18 and 20 (see committee's report in the October issue) my impression is the same as Mr. Cartwright's that the Master Car Builders voted this fuse block down under a misapprehension. The committee felt that there was no good reason why it should not recommend as preferable the fuse block shown in Fig. 20 which can be manufactured more cheaply and which can be used with the fuse shown in Fig. 25 on page 516. The committee also could see no reason, in case the recommended practice should be promoted to standard practice, for requiring all roads to use one single fuse block in place of whatever fuse block they were using, which under the M. C. B. rules they would have to do if the fuse block in Fig. 20 was the only fuse block submitted. The idea of the committee is that all of the fuse holder shown will be standard but that on all new work the one which should be installed is the one recommended but that the fuse blocks shown in Figs. 16 and 18 will still be allowed to continue because they are already in use. The same fuse can be used by using the fuse holder or blocks that are shown in Figs. 22 and 26 respectively on page 516.

A motion was passed that the committee report be referred to letter ballot, especial attention being called to the fact that all of the recommendations with the exception of the fuse block haye been accepted by the M. C. B. association and that in the judgment of the convention the one point which they turned down should be accepted by our association as the M. C. B. committee intended to re-submit it next year.

J. J. Hack (So. Pac.).—We have not been getting anywhere near satisfactory light out of our batteries on the head-end train between Oakland and Chicago, which we operate jointly with the Chicago & North Western and the Chicago, Milwaukee & St. Paul. Two months ago I installed a Sangamo meter on several cars, unknown to the train crew, and found some curious results. In some cases the batteries were being greatly overcharged, in others they were not being charged near enough. Agreeing with Mr. Sloan I do not see how the man located in the baggage car can charge the batteries properly. Personally, I believe the Sangamo meter would be a great help to the man in the baggage car in properly charging his batteries.

F. W. Reed (Nor. Pac.).—It is difficult, with the head end system, to determine the condition of charge of each battery on the train and it is simply a matter requiring that the charge be continued at the proper voltage until, due to the taper charge, the current has been reduced to a minimum. In my opinion the ampere hour meter control in connection with the head-end system would be advisable. We have experienced trouble in obtaining a full charge on cars in the rear of the train and to take care of this situation have tried out a resistance in series with the batteries on the first cars in the train.

J. R. Sloan (Penn.).—Can the man at the switchboard, by watching his meter, tell what amount of current is going to each battery?

F. W. Reed (Nor. Pac.).—He cannot.

A. J. Farrelly (C. & N. W.).—After about 16 years' experience with batteries in connection with head-end train lighting, I have come to the conclusion that it is necessary to have something automatic in connection with the battery which will cut it out when fully charged regardless of who is handling the dynamo and which will cut in the battery again when it requires a charge.

J. J. Hack (So. Pac.).—We find on our report "Charged battery observation car nine hours; charged battery on dynamo cars seven or eight hours." This charge is given in many cases irrespective of the condition of the batteries when they were first put on charge. For this reason it would be desirable to use a Sangamo ampere hour meter either in connection with an automatic device to cut out the batteries when charged and cut them on again when necessary or even to keep a check on the men in charge of the dynamo. A Sangamo ampere hour meter if kept in order has considerable merit and I think it would increase the life of our plates considerably. It has been my experience that the dynamo men paid more attention to their batteries after they found out that I had a meter on the car.

J. A. Andreucetti (C. & N. W.).—I agree with Mr. Hack that an automatic device is necessary. With the system used by Mr. Hack it is possible to keep a record of the number of ampere hours going into the battery but with it there is no way to tell whether the battery is charged or not and there is no way of preventing an overcharge.

W. L. Bliss (U. S. L. & H. Corp.).—It seems to me that when charging batteries on head-end trains if there is only one battery to be considered and no automatic devices are employed whatever, the guessing is in its simplest term, if there are two batteries the guessing becomes a little more complicated, but when there are half a dozen batteries the guessing becomes hopeless.

J. R. Sloan (Penn.).—In regard to standardization of ball bearings on axle generators: This matter was definitely settled some years ago, at which time practically all such generators were truck mounted so that we standardized on ball bearings No. 412. Since that time generators for suspension from the body of the car have been developed and I have been informed that the manufacturers are using all kinds of bearings for this type of generator. I suggest that the committee of standards take up this question with the idea of standardizing the ball bearings for the body suspended generator. Mr. Sloan incorporated this suggestion as a motion which was carried.

Metal Conduit Specification

The committee verbally reported that extensive tests are now being made but have not been concluded and gave the following as an outline of what has been done to date: Practically all makes of conduit have been under test for over a year under varying conditions such as exposure to sulphur, gases, salts, etc., but the time that has elapsed since subjecting the test pieces to the action of these agents has not been sufficient to bring out any definite information.

J. R. Sloan (Penn.).—We obtained samples of conduit as manufactured by all the various conduit makers in the country and in getting these samples we enlisted the aid of the National Board of Fire Underwriters who had their representative pick samples of conduit as it was manufactured. In this way we did not get conduit which we might have if we had gone to the manufacturers who would probably have given us something extra good. On the other hand, if we had gone to a jobber we might have gotten conduit which he had had in stock for several years. In addition to the regular conduit we have obtained samples of some Byers wrought iron pipe and we have some plain galvanized pipe and pipe with special coatings. We are bending the samples to 90 deg. and are painting one end, leaving the other end unpainted to show the effect of the paint. We intend to place some of the samples on the roof of the test department building, which is near the locomotive test plant, so that the sulphur gases there are very strong. Other samples are placed on signal bridges, some are placed in New York where they are exposed to salt water conditions and others are being buried in the yard in which we have had poor results from all kinds of conduit and where the soil conditions seem to be extremely bad. In my opinion it will be two years and possibly more before we will be ready to report. We are making tests of the weight of these samples on a three months' basis and in special cases, if there is anything worthy of note, we are having photographs taken.

The report was accepted as a progress report.

Election of Officers, A. R. E. E.

The following officers were elected to serve the association during the year 1916-17: President, C. J. CAUSLAND, Pennsylvania; Vice-President, J. E. GARDNER, Chicago, Burlington & Quincy; Executive Committee, Western district, A. E. VOIGT, Atchison, Topeka & Santa Fe; Eastern district, C. H. QUINN, Norfolk & Western.

Place of Meeting Next Year

It was decided that the semi-annual meeting would be held at the same time and place as the June meeting of the American Railway Master Mechanics' and the Master Car Builders' Associations, and that the annual meeting of the association will be held at Chicago, the date to be selected by the executive committee.

Election of Officers of the R. E. S. M. A.

At the annual meeting of the Railway Electric Supply Manufacturers' Association the following officers were elected to serve for the ensuing year: President, F. F. SKEEL, Crouse-Hinds Company; Senior Vice-President, AZEL AMES, Kerite Insulated Wire & Cable Company; Junior Vice-President, J. H. RODGER, Safety Car Heating & Lighting Company; Secretary, J. SCRIBNER, General Electric Company; Treasurer, EDWARD WRAY, Sangamo Electric Company. The members of the present Executive Committee are E. L. CALLAHAN, Westinghouse Lamp Company; GEORGE BERGER, Gould Storage Battery Company; C. W. BENDER, National Electric Lamp Association; L. J. KENNEDY, Consolidated Railway Electric Lighting & Equipment Company; R. N. NEWBOLD, Willard Storage Battery Company; W. S. BAUER, Edison Storage Battery Company; THOMAS ATKINS, Electric Storage Battery Company; D. WOODHEAD, Central Electric Company; H. A. MATTHEWS, United States Light & Heat Corporation.

The new members which were elected this year are: Messrs. WOODHEAD, ATKINS, KENNEDY and MATTHEWS, taking the place of I. W. JOHNSON, Pyle-National Company; H. E. WATKINS, Benjamin Electric & Manufacturing Company; GEORGE H. PORTER, Western Electric Company, who have retired, and J. H. RODGER, who has been elected Junior Vice-President.

Manufacturers' Exhibits at the A. R. E. E. Convention

October 31—November 3, Chicago

Adams & Westlake Company, Chicago.—Straight and drop handle car brake; roundhouse headlight and lighting fixtures. Represented by W. J. Pierson, A. S. Anderson, G. L. Walters and J. F. Fender.

American Pulley Company, Philadelphia, Penn.—Pressed steel armature pulley made up in the form of standard American pulleys, the rim being composed of two pressed steel parts riveted to a drawn steel hub ring. No rivets in face of pulley, therefore, to cut the belt. They also showed their tapered axle bushing and split pressed steel axle pulley with both the straight and flare cut flanges, the latter being for use in connection with the body hung generator. Represented by J. S. Crapp and J. F. Forrest.

Anderson Manufacturing Company, Albert & J. M., Boston, Mass.—This company had on exhibit two panels on which were mounted a complete line of receptacles and plugs for battery charging and general commercial service. Several types of plugs and receptacles were also displayed on two tables in their booth. A new line of charging plugs and receptacles known as the A B C type used for lighting and power service were on display. They are made up with single, two, three and four poles and with capacities ranging from 50 to 150 amperes. Such receptacles are especially suitable for portable conveyors on docks and for connections to portable tools in railroad shops, etc. This company also had on exhibit a number of improved types of receptacles and plugs for yard charging purposes. Represented by B. G. Durham.

Benjamin Electric Mfg. Co., Chicago.—Reflectors, Benjamin "Safety Flush" receptacles, the latter being open on both sides of the line except when a lamp or plug is screwed into it and Starrett panel boards. Several new fixtures for gas filled lamps were on exhibit which were of both the deep and the shallow bowl type constructed of steel and finished in baked enamel. A complete line of reflectors with the S type holders were shown which can be used with "Benco" sockets and outlet box receptacles and covers, the complete line being interchangeable. Represented by H. E. Watson, R. C. Mons, G. B. Weber and A. E. Lubeck.

Bennett Company, I. A., Chicago.—Exhibited a complete line of "Sherarduct" and "Economy" metal conduit and "Krantz safety auto lock" switches. Represented by H. J. Newton.

Central Electric Company, Chicago.—A complete line of Okonite wire and splicing tape. The exhibit booth was illuminated by one of the new "Four in One" fixtures which have been developed for station lighting. This fixture is similar to the Maxolite fixture handled by this company except that the reflector is of porcelain and the lamp is enclosed in an enameled glass bowl designed to give perfect diffusion. This fixture will take any size of the gas filled lamp from 100 to 500 watts and is represented as being dust and bug proof. The socket case is of weatherproof enameled steel. A complete line of "Ralco" plugs and receptacles, D. & W. fuses, "Central Diehl" fans and Maxolites were also on exhibit. A new fan that is being put on the market by this company is known as the "Huc" indirect fan; it was described in the July, 1916, issue of the *Railway Electrical Engineer.* The line of Maxolite fixtures has been greatly added to this year and is now very complete. The two new types that attracted especial attention are the deep bowl and the skirted cone. This company also showed a set of distribution curves, including a blueprint curve for each one of their Maxolite fixtures which they are sending to railroad electrical officers to aid them in their illumination calculations. Represented by E. C. Wilson, J. M. Lorenz, L. G. Martin, D. Woodhead, R. N. Baker and A. L. McNeil.

Consolidated Railway Electric Lighting & Equipment Company, New York.—Axle generators, including their standard two k. w., 40-volt, 50-ampere interpole ball bearing machines, which are equipped with an improved type of pole changer. A new body hung generator, consisting of a standard machine with supporting lugs redesigned for body mounting, was also on exhibit. A type L-3 generator regulator with ampere hour meter control was mounted for inspection together with their type L lamp regulator. A new motor driven lamp regulator was exhibited for the first time. This regulator is similar to the type L with the exception that the plunger coil, instead of operating the ratchet contact, simply engages a pawl which enables the motor, mounted on the top of the regulator, to move a sliding contact over the top of the resistance grid commutator by a rack and pinion and crank movement. Represented by Thos. L. Mount, W. R. Hungerford, L. J. Kennedy and D. N. Balderson.

Crouse-Hinds Company, Syracuse, N. Y.—Condulets, panel boards, roundhouse headlights, switches, charging receptacles and plugs, flood lighting units and car lighting fixtures. Among the new equipment developed by this company and which was exhibited for the first time is a new car vestibule fixture consisting of a socket and reflector which can be removed separately without disturbing the wiring. This fixture is known as the R S series. A new flood lighting unit was also shown consisting of a cylindrical case fitted with a 16-in. silvered reflector taking a 500 watt concentrated filament flood lighting lamp. The socket for this unit is equipped with a focusing attachment. The Crouse-Hinds safety first switch of the new M K series was also shown for the first time; this switch is simply a starting switch entirely enclosed in a cast iron case with a hinged separate cover for the fuse compartment. With this switch it is impossible to remove the fuses while the switch is closed and it is also impossible to close the switch while the cover which exposes the fuses is open. Represented by F. F. Skeel, Charles Dubsky, J. A. Amos, Edward Otto, E. G. Smith, Charles Gurney and C. H. Bissell.

Cutter Company, George, South Bend, Ind.—Panel boards, lighting fixtures, reflectors, ornamental lighting columns and cutout pulleys. Represented by O. B. Duncan and F. R. Carl.

Edison Storage Battery Company, Orange, N. J.—Edison nickel-iron car lighting batteries. A number of these cells were exhibited on pedestals, a portion of each cell being cut away so as to show all of the structural details. Represented by H. G. Thompson, F. V. McGinness, W. F. Bauer, H. M. Roberts.

Davis Lighting System, Chicago.—A complete line of flood lighting units. The various sizes of flood lighting units as manufactured by this company were on exhibit, as were also several photographs showing representative installations. Represented by W. J. Davis, F. M. Evans and W. O. Turtle.

Electric Service Supplies Company, Philadelphia, Pa.—"Golden Glow" headlights, Darling-Henrici headlight turbo-generator equipments, "Garton Daniels" arresters, Keystone lamp guards and Keystone plug pins for high tension insulators and "Locke" Hi-tension insulators. This company now manufactures the Darling-Henrici headlight generator which will be known in the future as the "Keystone" turbo-generator. These machines are built for either 32-volt, 500-watt, or 6-volt, 300-watt. This company has also taken over the "Golden Glow" headlight, which is especially adapted for use on locomotives, marine equipment and docks. The standard headlight is 12-in. in diameter and will take lamps from 100 to 250 watts of the headlight type. A flood lighting unit based on the Golden Glow principle was also exhibited which had a 12-in. reflector and which was equipped with a 250-watt flood lighting lamp. An interesting part of the exhibit were glass reflectors in the various stages of manufacture. Represented by Charles J. Mayer, J. W. Porter, L. A. Darling, O. Mueller, Thomas H. Hinckle.

Electric Storage Battery Company, Philadelphia, Pa.—E. S. B.

axle lighting equipment, including truck and body hung generators, car lighting switch-board panels, car lighting storage batteries, in a two-cell, lead lined tank of slotted crate construction. A two-cell unit with rubber jars was also exhibited. Represented by G. H. Atkin, J. Lester Woodbridge, H. M. Beck, H. E. Hunt and O. R. Shortall.

Fairbanks, Morse & Co., Chicago.—A special display of type C. P. B. direct current and type H alternating current, ball bearing motors with upper part of the motor frame cut away in each case to show the motor construction details, also to show installation and action of the ball bearing during actual operation. Even though almost half of its field frame was cut away the direct current motor was running from an 8-volt storage battery. The motor consumed five amperes or 40 watts, of which more than one-half was consumed in the field. This demonstrated the low friction losses in the ball bearing. The alternating current motor was run by a small auxiliary motor as no alternating current was available. It was interesting to note, in both motors, the small amount of space taken by the ball bearings as compared with sleeve bearings. The compactness of the design, permitted by the use of anti-friction bearings, effects a considerable saving in the floor space taken by the motor. The small air gap made possible by the use of ball bearings on the alternating current industrial motor was also noticeable; the small air gap increasing the efficiency of the machine.

The type H induction motor was equipped with the standard Fairbanks-Morse solid metal rotor winding commonly known as a cast end ring. A section of this ring was shown under a high power glass to show the perfect fusing of the rotor bar with the end ring. This company also exhibited a new auto starter, the special feature of which is the construction of the contactor finger. The tips of the contactor finger are removable and reversible so that in case one side becomes pitted and burnt, due to arcing, the finger can be removed and turned around to present a clean surface. In this way double the life of the ordinary contact finger is assured. Represented by A. A. Taylor, M. Whitell, F. M. Condit, K. P. Brown and M. O. Southworth.

Franklin Railway Supply Company, New York.—Stone-Franklin axle generator and car lighting switchboard panel. A standard Stone-Franklin T-35 axle generator, equipped with the unique output indicator supplied by this company, was on exhibit. The switchboard shown consisted of a main light panel, a type L ampere hour meter panel and a type C generator control panel. The original Stone system, as used abroad, is hardly recognized in the modern equipment exhibited by the Franklin Railway Supply Company, as a large number of improvements and refinements have been made to meet American car lighting practice and standards. Represented by Floyd Coffin, H. D. Rohman and Henry Kloos.

General Electric Company, Schenectady, N. Y.—Exhibited a 6.5 volt, 175 watt turbo-generator headlight equipment with headlight case and reflector. Represented by C. C. Bailey, S. W. McCune, Jr., B. F. Bilsland and J. Van Kerokhove.

Gould Coupler Company, New York.—Standard Gould "Simplex" car lighting switchboard panels, truck and body hung axle generators and car lighting storage batteries. In addition to the above a model of the Gould axle generator pole changer was shown in section which could be operated by turning a crank together with a complete shaft, fitted with all bearings. Besides the standard truck mounted axle generator, two generators of the body-hung type were exhibited, one being the standard machine inverted and attached to a casting designed to fit the feet of the standard machine, and the other a new moderate speed body-hung machine, known as type R, especially designed for "Underframe" mounting. This machine is designed for a three to one speed ratio while the standard machines are designed for a two to one speed ratio. Both machines have a cutting in speed of approximately 18 m. p. h. The important features of the new machine are the accessibility of the pole changer, which is exposed by taking off a pressed steel dome, and the provisions made for ventilating the pole changer compartment. Represented by G. R. Berger, W. F. Bouche, P. H. Simpson, J. O. Ashton and M. R. Shedd.

Harter Manufacturing Company, Chicago.—Standard lines of Harter lighting fixtures, including the De Luxlite, a new all white self reflecting fixture and the new hinged "Nitrolites." Represented by G. A. Harter, William Soffe, D. M. Ayers, D. E. Warrel and F. Pitchardt.

Hart & Hegeman Manufacturing Company, Hartford, Conn.—Exhibited two panel boards on which were mounted a variety of the different types of railway snap and push button switches, indicating switches and other wiring devices including pipe taplets, sockets, etc. This company is handling all of the Paiste products as selling agents. Represented by W. W. Winship, H. L. Everett, Jr., and F. C. Church.

Ivanhoe-Regent Works of General Electric Company, Cleveland, Ohio.—Lighting fixtures, glass and metal reflectors.

Kerite Insulated Wire & Cable Co., New York.—Samples of wire and cable manufactured by this company. Represented by Azel Ames, J. M. Hamilton, P. W. Miller, W. H. Findley and J. A. Hamilton.

National Lamp Works of General Electric Company, Cleveland, Ohio.—An interesting and instructive exhibit of Mazda lamps on three fumed oak frames. One frame contained a complete line of miniature Mazda tungsten lamps, the second frame showed the new locomotive headlight and flood light lamps of the following descriptions: 115-volts, 250-watt flood light; 115-volt, 500-watt, flood light; 32-volt, 100-watt headlight; 32-volt, 250-watt headlight, and 6-volt, 108-watt headlight lamps. On the third frame were mounted three rows of standard train lighting and commercial Mazda tungsten lamps including two sizes of the new daylight lamp. A color matching unit was also shown which gave a light equivalent to that of a north skylight. Another interesting feature of the exhibit was a demonstration of the color quality of incandescent lamps. Four types of lamps were mounted in separate partitions of a wooden box in such a way that a lamp of each of the four types illuminated similar strips of colored ribbon. The lamps themselves could be viewed from the front through colored glass. The lamps used were (1) Mazda C-2 (daylight), (2) Mazda C (gas-filled), (3) Mazda B (vacuum), and (4) Gem (metallized carbon). It was evident from this demonstration that the light from the daylight Mazda gave perfect daylight lighting and the correct color to the various ribbons, the gas filled Mazda was a close second while the vacuum Mazda and the Gem metallized carbon lamp showed considerable yellow light, the latter lamp being the worst offender in this respect. Represented by L. C. Kent, and C. W. Bender.

National Metal Molding Company, Pittsburgh, Pa.—Metal molding, sherardized conduit, flex-steel conduit, outlet boxes and a complete line of fittings for this material. Represented by H. C. Moran, and J. A. Bennett.

Oneida Steel Pulley Company, Oneida, N. Y.—Exhibited a standard 18 in. Keystone flaring flange pulley with Oneida corrugated bushing mounted on a model section of a car axle. Various types of bushing for standard tapered and straight axles of the various sizes were also shown. Represented by N. G. Stark.

Pass & Seymour, Syracuse, N. Y.—Exhibited a complete line of sockets, receptacles and wiring accessories, the special features of the display being "Shurlock" and double pole sockets and "one man" sign receptacles. Represented by D. R. Despard, L. A. Bishop, R. F. Crane and F. T. Haffner.

Pyle-National Company, Chicago.—Exhibited Type K and type H incandescent headlight equipments for 6 and 32 volts. Headlight cases with 18 by 9 in. reflectors for 250-watt incandescent lamps were shown, as was also a unique adapter with micrometer screw adjustment for adapting an incandescent lamp to old oil or arc headlight cases. The micrometer adjustment on the adapter provides a six way adjustment, both ways in three directions. This company also had on exhibit their standard single pole, double throw knife switches for cab wiring. This switch is substantially made and is particularly adapted to this class of work. Represented by Luther H. Steger, J. E. Kilker and J. Will Johnson.

Pyrene Manufacturing Company, New York.—Fire extinguishers. Represented by G. R. Henderson, F. P. Murphy, W. H. Getman and H. V. Flora.

Safety Car Heating & Lighting Co., New York.—Exhibited the three standard sizes of underframe axle car lighting generators, lamp regulator panels and car lighting fixtures both of a direct and semi-indirect type. Represented by A. C. Moore,

J. H. Rodger, G. F. Hulse, J. L. Marsh, C. A. Pinyard and W. H. Reader.

Schroeder Headlight Company, Evansville, Ind.—Incandescent headlight turbo-generators and other headlight equipment suitable for operation with 32-volt incandescent lamps. The generator is known as type R E 2 and is of 500-watt capacity. This machine was on exhibit for the first time but in general design is the same as the old 300-watt machine. An interesting part of the exhibit was a separate revolving unit from one of the 500-watt machines shown complete with turbine wheel and ball bearings. A headlight case for a 250-watt incandescent lamp with an 18 by 9 in. silvered copper reflector was also exhibited. This case is equipped with Baker patented number frames which require no screws. A 10-watt lamp is mounted inside the headlight case for illuminating the number plates. An adjustable stand was also shown which is used to adapt incandescent lamps to old oil and arc headlight cases. On this adapter all adjustments are made by loosening two thumb screws. The adapter is bolted to the bottom of the reflector slide. Represented by J. Henry Schroeder and George M. Price.

Sangamo Electric Company, Springfield, Ill.—Ampere hour meters, alternating and direct current watt hour meters. An interesting part of this exhibit was a standard ampere hour meter with a section cut away to show internal construction details. Represented by A. B. Southwick, C. H. Koehler, C. H. Hurtt and Edward Wray.

Thompson Electric Company, Cleveland, Ohio.—Exhibited a novel and practical safety cut-out hanger for hanging incandescent lamp fixtures and arc lamps from pole fixtures and in accessible places in railroad machine shops, etc. This cut-out is well made and at the same time is of much lighter weight than other devices of this character. Such a cut-out is extremely valuable for use around railroad yards and shops as fixtures installed with it are easily lowered for cleaning. They are also valuable as an accident preventive as their use enables fixtures to be cleaned and lamps renewed without the necessity of the lamp maintainers climbing poles and crawling out over trusses, up high ladders, etc. Represented by A. J. Thompson.

United States Light & Heat Corporation, Niagara Falls, N. Y.—Standard car lighting generators, switchboard panels, storage batteries, etc. The U. S. L. standard panel is equipped with ampere hour meter control and the lamp regulator has embodied in it a new feature consisting of a double pile of carbon disks which may be used either in parallel or series. The body hung generator, which was on exhibit, was cut away to show the construction details. The suspension for this generator is designed for center girder mounting and was displayed for the first time. This generator is simply a standard machine except that the frame has been redesigned without feet, it being fitted with an adapter single bearing lug instead which is hinged to a special bearing bolted to the fish belly or car girder. This machine is known as type C L A 15. A standard shaft for this machine complete with ball bearings was also on exhibit. A new lead storage battery plate has just been developed by this company and was on exhibit for the first time, it being known as type C L J. The distinctive feature of this battery is in the plate which is provided with diagonal ribs to give added strength so as to prevent buckling, also a beading about one inch from the bottom of each plate and directly above the triangular porcelain support is provided which will act as a solid support for the plate when it has been cut off at the bottom due to growth. Represented by R. C. Haley, H. A. Matthews, G. D. Ladd, W. L. Bliss and A. W. Donop.

Western Electric Company, New York.—Enclosed power switches, "Square D" switch boxes, lamp guards, industrial train lighting and headlight lamps. Represented by George H. Porter, J. C. Binning, T. J. Rider, Jr., and Harry Olmstead.

Westinghouse Lamp Company, New York.—Mazda locomotive headlight lamps together with other tungsten lamps of interest to railroad electrical men. Represented by W. H. Rolandson, A. N. Brown and J. G. Harvey.

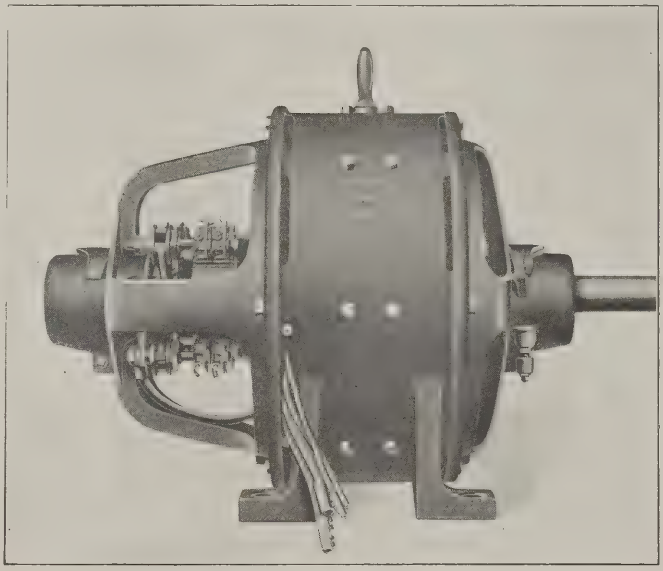
Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—Alternating current and direct current motors and direct current automatic control equipment. Represented by W. H. Patterson, R. L. McLellan, R. J. Ross, H. D. Mode and H. B. McKinney.

Willard Storage Battery Company, Cleveland, Ohio.—"No-Wash" batteries, plates and battery parts. An interesting part of the exhibit was one of the "No-Wash" batteries, part of which had been cut away to show internal construction details. Represented by L. Sears, E. L. Meyers, I. R. Wentworth and L. B. Knight.

Heavy Duty Motors

A newly developed heavy duty direct current motor has been developed by the Reliance Electric & Engineering Company, Cleveland, Ohio, in the design of which a unique plan was followed. All details were submitted to 35 electrical engineers in steel mill, railway and industrial service, and in each case the detail was selected which met the approval of the majority. In practically no case are more than 20 per cent of those consulted said to have favored details other than those selected.

The frame is a steel casting of rugged construction with heavy machined feet cast integral. The journal box housings in the brackets are of the ring oiling type and are provided with pockets into which sediment from the oil may settle. An overflow with an extra large opening is let out from this pocket and is designed to take care of oil as rapidly as it can be poured in at the oil well opening over the oil ring. The oil hole covers are self-closing of their own weight. The leads are brought out through a block asbestos board between the frame and commutator end bracket. This permits the removal of the end bracket by disconnecting the leads at the brush studs, which are readily accessible.



Reliance Heavy Duty Motor.

The bearings on both ends of the motor are interchangeable and are liberal in size. The armature shaft is also of unusual size and the armature is built on a spider so that the shaft can be removed without disturbing the windings. The brush holders are mounted on studs carried by a rocker and are removable without taking off the end yoke.

Special attention has been given to the design of parts which eventually will require renewal, in order that they may be replaced with the least possible trouble.

Shop Motor Section

XXII—Electric Meters

J. H. Wickman*

DURING recent years the adaptability of the voltmeter for testing has become more generally known, but it is still true that most electricians who use this instrument, although familiar with its construction, do not fully appreciate the advantage of using it for determining resistances and for making other special measurements. For this reason the following examples which demonstrate the special uses of the voltmeter are interesting and instructive.

Suppose we have a voltmeter provided with two scales, one from 0 to 150 in one volt divisions and the other from 0 to 15 in one-tenth volt divisions. We will also assume that the high scale coil has a resistance of 20,000 ohms and the low scale coil has a resistance of 2,000 ohms. Most all standard voltmeters have the resistance of the coils marked either on some part of the meter or on its case. In the following examples the 150-volt scale with the 20,000 ohms resistance will be used.

Voltmeter Method of Measuring Resistance

To measure the resistance of a coil of wire, a lamp or any other circuit with a voltmeter, the procedure is as follows:

R = Resistance of voltmeter—20,000 ohms in this case.
R1 = Resistance of coil or lamp to be measured.
D = Deflection of voltmeter when connected across the circuit which supplies the testing voltage.
D1 = Deflection of the voltmeter when connected in series with coil or lamp and across the supply circuit, that is the unknown resistance of the coil or lamp and the known resistance of the voltmeter are in series, which causes a smaller reading or deflection on the voltmeter.

The formula for solving this problem may be stated as a proportion,

$$R : R1 :: D1 : D = \frac{R \times D}{R1 \times D1} \quad \ldots\ldots\ldots\ldots (1)$$

Assume that the following values represent a specific case:

R = 20,000
R1 = Unknown
D = 110 volts
D1 = 105 volts

Substituting in the formula (1) we get:

$$\frac{20{,}000 \times 110}{R1 \times 105},\ R1 = \frac{20{,}000 \times 110}{105},\ R1 = 20{,}952 \text{ ohms}$$

This figure represents the sum of the voltmeter resistance and the unknown resistance as they are in series. Therefore, by subtracting 20,000 ohms we obtain 952 ohms as the resistance of the coil or lamp.

Another method that is often used to obtain the same result is represented by the formula:

$$R1 = R\left(\frac{D}{D1} - 1\right) \quad \ldots\ldots\ldots\ldots (2)$$

By substituting our known values in this formula we obtain:

$$R1 = 20{,}000 \frac{110}{105} - 1$$

and by removing the parenthesis,

$$\frac{110}{105} = 1.047619,\ 1.047619 - 1 = .047619 \text{ and } .047619 \times 20{,}000 = 952.38,$$

which is exactly the same result obtained by the other method.

The second formula (2) is based on Ohm's law, which states that the current I in any resistance R equals the impressed voltage E divided by the resistance.

$$I = \frac{E}{R} \quad \ldots\ldots\ldots\ldots (3)$$

Therefore formula (2) may easily be proved as follows:

In the diagram of connections for measuring an unknown resistance with a voltmeter shown in Fig. 75, *D* is the voltage of the testing circuit, *D1* is the voltmeter deflection, *R* is the voltmeter resistance, *R1* is the unknown resistance and *I* is the current flowing in the circuit.

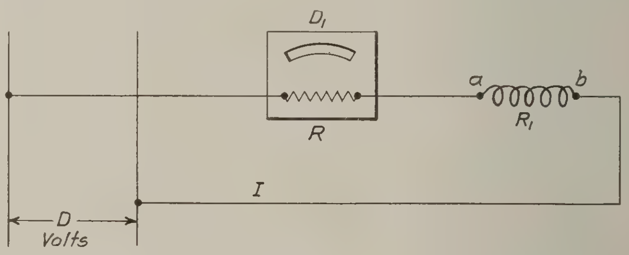


Fig. 75. Diagram of Connections for Measuring an Unknown Resistance with a Voltmeter

It is evident that the voltage across *R1* is equal to the circuit voltage minus the voltmeter reading, or *D — D1*. Therefore from Ohm's law (3) the unknown resistance R1 is equal to the voltage impressed across it divided by the current flowing in the circuit, or

$$R1 = \frac{D - D1}{I} \quad \ldots\ldots\ldots\ldots (4)$$

If we can now find an expression for the current *I* in terms of *D* and *R* we can substitute in formula (4) and thus get an expression for *R1* in terms of voltage and resistance only, which is what we want.

As this current, when flowing through the voltmeter resistance *R,* causes a voltmeter reading of *D1,* which is the drop over that resistance, we may, by using Ohm's law again, make the following expression for the current in terms of *D1* and *R*:

$$I = \frac{D1}{R} \quad \ldots\ldots\ldots\ldots (5)$$

Now substituting this value for I in formula (4) we have

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*General Foreman, Electrical Department, Illinois Central, Chicago.

$$R1 = \frac{D - D1}{\left(\frac{D1}{R}\right)} = \frac{R}{D1}(D - D1) = R\left(\frac{D - D1}{D1}\right) = R\left(\frac{D}{D1} - 1\right)$$

which gives us the formula we wished to prove.

Testing Insulation

The voltmeter is also used for testing the insulation resistance of a circuit, machine or system.

The insulation resistance is measured by connecting one terminal of a 500-volt direct-current supply to one of the machine terminals through a voltmeter with a 500-volt scale, and connecting the other 500-volt terminal to the frame. It is necessary, however, to first take a reading of the testing voltage which is represented by *D* in the above formulæ and care should be taken to keep this voltage constant. The connections are the same as those shown in Fig. 75 except that the unknown resistance *R1* is the insulation around the windings instead of a coil of wire or other metallic resistance. In this case *a* is connected to one of the machine terminals while *b* is connected to the shaft or to some other part of the machine frame. Either formula 1 or formula 2 may be used. The same method applies when measuring the resistance of any circuit or wiring system, or of a partial ground.

Wattmeters

In direct current circuits the product of volts and amperes read from a direct current volt and ampere meter equals the true power of the circuit in watts. However, this is not the case with alternating current unless the power factor of the circuit being measured is unity. In alternating current circuits it is necessary to measure power in watts with a watt meter.

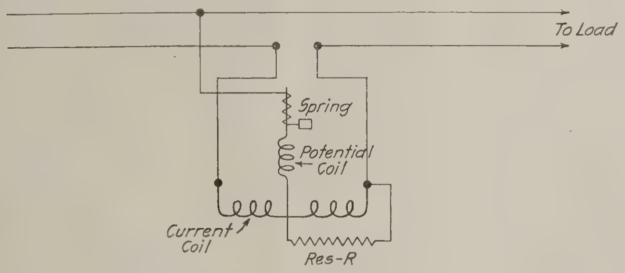


Fig. 76. Internal Connections of a Direct Current Wattmeter

The principle of construction of the direct current watt meter is shown in Fig. 76. The series or current coil, which is the stationary coil, carries all of the current flowing in the circuit being measured, while the movable or potential coil is connected across the circuit. It will be noted that there is an external resistance *R*, in series with the potential coil; therefore, very little current passes through this circuit.

The potential coil is carried on the shaft which carries the indicating needle, and its deflection, which is retarded by a spring, continues until the fields of the two coils concide in direction. The deflection of the needle or rotation torque of the movable coil is proportional to the currents passing through the two coils at any instant, or if the load varies rapidly, the watts indicated are the average, or zero in case no current is flowing through the current coil.

Induction Wattmeter

It will be noted with reference to Fig. 77 that the induction wattmeter is connected to the load in the same manner as the direct current wattmeter shown in Fig. 76, that is the current coil is in series with the load and the potential coil is across the circuit. However, in this case both of the coils are stationary and have laminated cores between which is the movable part consisting of a disk or vane *V*. The alternating current in passing through the coils sets up an alternating magnetism in the vane or disk which reacts on the fields, the reaction being proportional to the current flowing in the coils. This causes a proportionate deflection of the needle, which is attached to the vane.

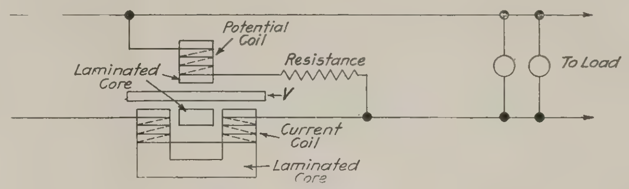


Fig. 77. Internal Connections of an Induction Watt-Hour Meter for Single-Phase Circuit

The induction wattmeter is made in a polyphase type by providing two separate elements, but both vanes attached to the same shaft or indicating hand. In other words the polyphase meter is a combination of two single-phase meters in one case. The connections of a polyphase wattmeter are based on the same principles as those governing the connections of a single-phase wattmeter. Simple connections for a polyphase meter with the cores and resistance omitted are shown in Fig. 78. In the three-phase connection shown the potential for both elements is taken from the same wire but in two-phase work the potential for one element is taken from the wire shown dotted, at the same time breaking the connection shown at *X*.

It is hardly necessary to mention the uses of the wattmeter, as it is universally used for all power and lighting work at stations, for testing, etc. The wattmeter used for testing will be described under watt-hour meters.

Measurements of Power

The wattmeter connections shown in Figs. 76 and 77 are correct for two-wire direct current and single-phase circuits, and the connections shown in Fig. 78 are correct for an unbalanced or a balanced two or three phase circuit. However, it is often necessary to ascertain the power passing through a three-phase circuit when a polyphase wattmeter is not available. This can be done by connecting the current coil of a single-phase wattmeter in series with one line *B* as shown in Fig. 79, and maintaining a steady load. The potential is first connected to

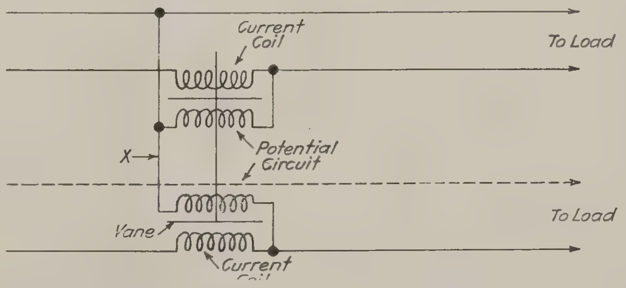


Fig. 78. Internal Connections for a Polyphase Induction Watt-Hour Meter

C and a reading taken, then to *A*, as shown by dotted lines, and another reading taken. The sum of the two readings will be the total power taken by the load if the power factor is greater than .5, but if less than .5 it will be the difference of the readings. Where possible, however, one polyphase or two single-phase meters are recommended for taking measurements on two or three phase circuits.

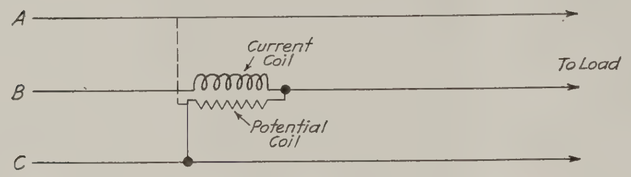


Fig. 79. Diagram of Connections for Measuring Three-Phase Power with One Watt-Hour Meter with a Balanced Load

Watt-Hour Meters

If the movable elements of a direct current wattmeter are replaced with an armature, or if those of the single-phase induction wattmeter are replaced with a circular disk and if both types of meters are equipped with permanent magnets to govern the speed of rotation they become recording instruments which rotate at a speed proportional to the current passing through the current coils. Further, if the meter is calibrated to include the element of time it becomes a recording watt-hour meter.

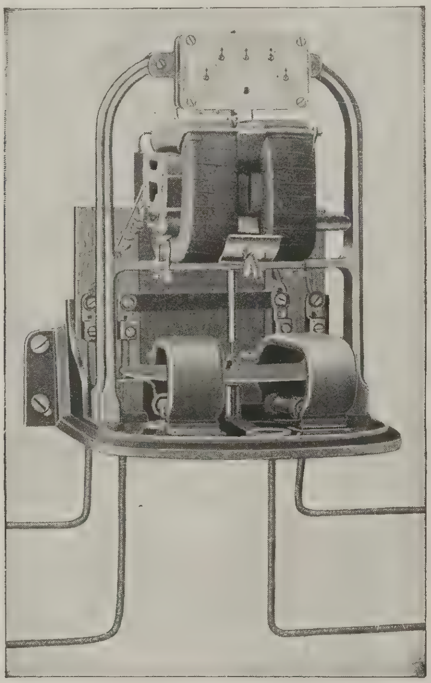


Fig. 80. General Appearance of the Thomson Recording Watt-Hour Meter for Single-Phase Circuit with Case Removed

It should be stated here that ammeters, voltmeters, indicating wattmeters and similar apparatus are, strictly speaking, instruments and not meters as they merely indicate amperes, volts and watts without respect to time, which is included in all units of energy. For this reason the only real meters are those instruments which measure ampere-hours, watt-hours or kilowatt-hours, etc.

Thomson Recording Watt-hour Meter

The general appearance of the Thomson recording watt-hour meter with the case removed is shown in Figs. 80 and 81. A few examples to show the typical connections of a recording watt-hour meter will be given. Space does not permit a detailed explanation of all the different makes so the more common ones will be used for purposes of explanation. It is hoped that the student will get enough ideas from those mentioned to be able to handle any type or make.

Installing Direct-Current Watt-Hour Meters

The following general rules apply to all types of d.c. watt-hour meters. Before installation the revolving disk must be released by removing the small wedge that is placed between the disk and magnet to hold it steady and away from the jewel bearing during shipment. The jewel bearing at the bottom is either loosened or removed during shipment and must be restored to its natural position before the meter is put into operation. House meters should be placed between the line switch and the load and meters used for motor work should be placed between the line switch and the motor switch so that the armature will always be excited.

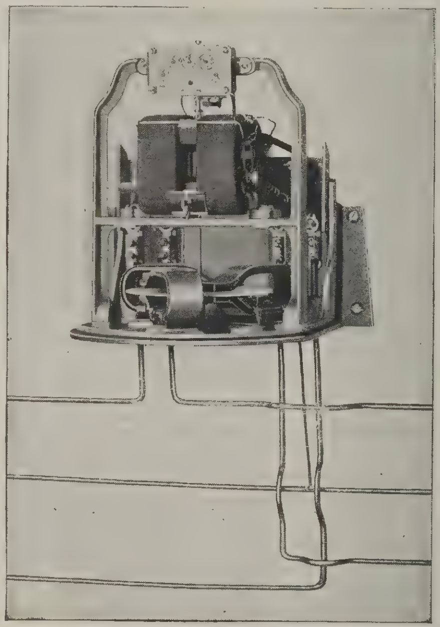


Fig. 81. The Polyphase Thomson Recording Watt-Hour Meter with Case Removed. The Photograph Shows the Wiring for a Three-Phase Circuit

The disk should always revolve to the right or clockwise looking from the bottom. It is good practice to turn the disk around a few times by hand to make sure that it revolves freely and also to make sure that the brushes make good contact on the commutator. The commutator of this type of meter should be regularly inspected and cleaned. This can be done by using a small piece of crokus cloth on the commutator once in every six months. With voltages higher than the common lighting voltage an external resistance box must be used in connection with the exciting circuit and it is important that this box bear the same serial number as the meter.

Adjustments

Whenever this type of meter is to record a load that varies from 3 to 1200 amperes, a special adjustable shunt is provided which makes it more accurate on the lighter loads. This adjustable shunt is placed in the left hand field coil when used in connection with a two-wire meter, as shown in Fig. 80 and in the right hand field when used on a three-wire meter, shown in Fig. 81. Meters of high current capacity have two adjustable shunt field coils either or both of which can be used for making light load adjustments.

If a meter of this type is found to be inaccurate the shunt field can be moved either closer to or away from the armature as necessary. Moving it away will decrease the armature speed and moving it nearer will increase the speed.

The detail connections for the three-wire meter with the adjustable shunt field coil are shown in Fig. 81. A detailed view of the shunt in the right hand field of the meter in Fig. 81, is shown in Fig. 82.

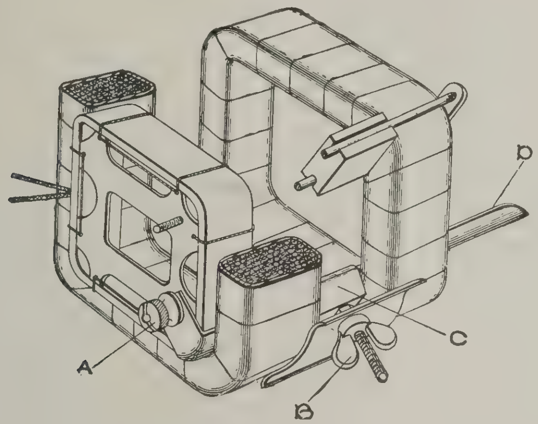


Fig. 82. A Detailed View of the Shunt in the Right-Hand Field of the Meter Shown in Fig. 82

This type of meter is often used on alternating current lines where it will operate equally as well and accurately as on direct current. It must be borne in mind, however, that current and potential transformers must be used on high potential circuits or on circuits where the current is excessive.

Any recording watt-hour meter is easily tested for accuracy, by comparing it with another watt-hour meter known to be accurate, both connected in series, and checking the readings after a long run. If the standard meter has recorded more than the one being tested it shows that the latter is slow and the speed can be increased by moving the magnets that surround the disk towards the armature shaft. If the meter is fast the magnets should moved outward. Another practical test is to compare the watt-hour meter with a standard ammeter and voltmeter or a portable standard wattmeter as shown by the connection diagram in Fig. 83. The amperes times the volts gives the actual watts passing through the meters. The recording watt-hour meter *M*, which is being tested, registers watts =

$$\frac{R \times K \times 3600}{T}$$

where R is the number of revolutions the disk makes in T seconds. K is the watt-hour constant of the meter which is always marked on the dial and 3600 is the number of seconds in one hour. The percentage of accuracy =

$$\frac{R \times K \times 3600 \times 100}{T \times \text{amperes} \times \text{volts}}$$

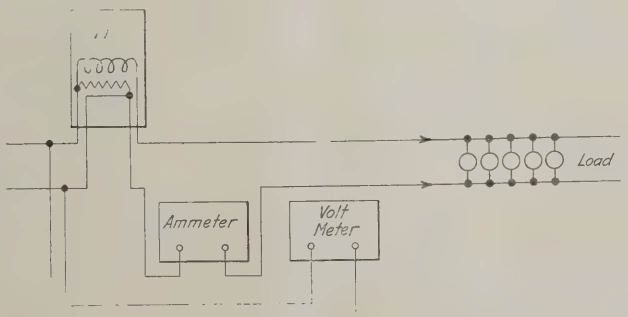


Fig. 83. A diagram of connections for Testing the Accuracy of the Watt-Hour Meter by Comparing It with a Standard Ammeter and a Standard Voltmeter. For Three-Wire Meters Each Current Coil Should Be Tested Separately and Then in Series.

For an example assume that a lighting load, which is steady, shows 8 amperes at 110 volts on the portable standard instruments. The true power is then 880 watts. The recording meter being tested has a constant of ½ and the disk makes 31 revolutions in 60 seconds. What is the percentage of accuracy?

Substituting in the formula we have

$$\frac{31 \times 0.5 \times 3600 \times 100}{60 \times 8 \times 110} = 105.68 \text{ per cent,}$$

which is the percentage of accuracy. The watt-hour meter being tested is therefore running 5.68 per cent fast and the damping or retarding magnets must be moved out from the shaft until 100 per cent accuracy is obtained.

Example: What would be the number of meter revolutions in the above example when the meter is recording accurately on the given test load?

Substituting and solving for R

$$880 = \frac{R \times 0.5 \times 3600}{60} \qquad R = 29.33 \text{ r. p. m. Ans.}$$

Whenever checking a meter a good stop watch should be used, and two or three trials should be made before moving the magnets so as to avoid personal errors.

Duncan Integrating Watt-hour Meters

The Duncan recording watt-hour meter is similar to the Thomson in construction. One marked difference is that the Duncan meter has a small switch that is used for light load compensation. This is a multiple switch on the front of the back casting. If the speed of the meter is too slow on light loads (5 per cent of the meter capacity and under) the error is corrected in an instant by moving the lever of the switch towards the left marked *Fast*, or if the speed is too high the lever is moved towards the right marked *Slow*. To correct the speeds for loads greater than 5 per cent the magnets must be moved as the compensating switch is only to correct inaccuracies at light loads and to overcome the friction of the bearings.

Testing

The testing methods just explained also apply to the Duncan meter, and the same formula is used. The testing constant is marked on the revolving disk of each meter. This constant should be used for testing purposes only, never when reading a meter.

Elevating Platform Truck

The Elwell-Parker Electric Company of Cleveland, Ohio, has placed on the market a new platform elevating truck which has been designed after a careful study of industrial conditions and extended tests in actual operation. The truck embodies many of the features common to all Elwell-Parker trucks, as well as many new features which will especially interest mechanical department officers. The operator must stand in an upright position on the small platform in front. In his right hand he has the steering lever which he merely points in the direction he wishes to go; in his left hand is the controller handle which he pulls up to go forward at any one of three speeds, releases to stop, and pushes down to reverse. The brake is automatically applied by the operator raising his right foot, and it has such a high efficiency that the truck will stop in 14 in. when going at full speed. The instant the operator leaves the truck, even though running at full speed, the brakes are applied, automatically; the controller goes to the "off" position, the circuit to the motor is disconnected and the machine is locked until he again returns to the operating platform. All of these features have been highly commended by safety-first organizations throughout the country.

The loading platform is only 11½ in. over the floor, making it possible to carry greater loads, and offering a great advantage in loading heavy packages. The steering is accomplished by all four wheels automatically taking the same radius of curve, permitting operation in narrow aisles and under congested conditions.

The driving mechanism is a worm gear operated by a motor, both simple and rugged in construction. The operator merely runs the truck under the loaded platform, starts the motor and the platform loaded with 4,000 lb. is raised 3 in., resting securely on the truck. The lifting device automatically stops itself when the platform reaches its maximum height and the truck takes the load to any point desired; then the platform is lowered without jolt or jar and the truck is run out from under it. It requires 10 seconds to lift the platform loaded with 4,000 lb. and seven seconds to drop it. The wooden loading platforms can be made at small cost to meet special conditions.

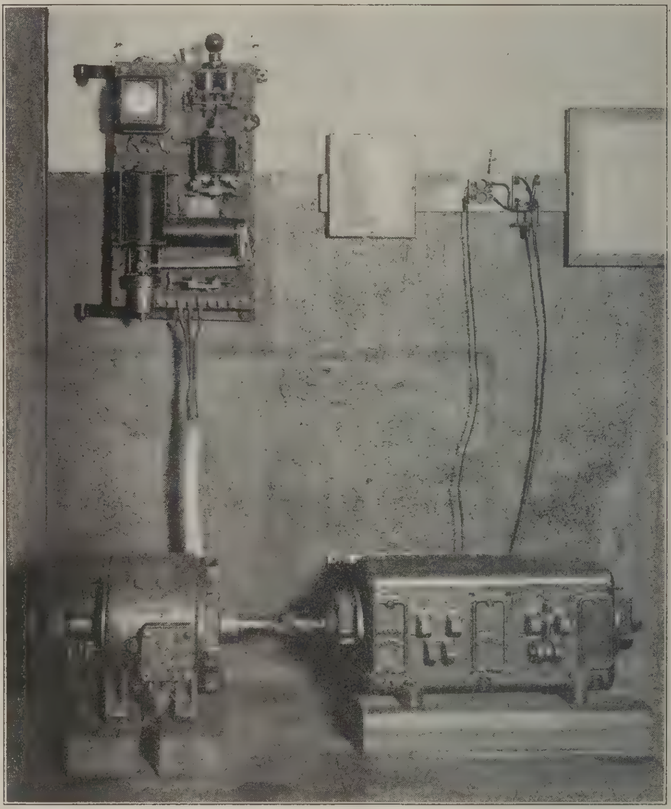
It is not necessary for the operator to leave the truck when lifting or lowering the load and it is evident that there will be a saving in time and labor by the use of this machine, to say nothing of its possibilities in increasing the output and decreasing the cost of production. Vanadium steel and drop forgings are used; also Timken and Hess-Bright ball bearings, Goodrich or Goodyear solid rubber metal base tires, etc.

Pullman Instruction Panel at the Sunnyside Yards

The illustration shows a test panel and test equipment which is used by the Pullman Company in the Sunnyside yards of the Pennsylvania Railroad, New York, for instructing car lighting men in the operation of standard Pullman car lighting equipment.

A type "M" U. S. L. generator is direct connected to one of the old "Bliss system" buckers the motor element of which is used to drive the generator. Any kind of a motor for driving the generator may be used. A standard Pullman regulating panel is secured to the wall immediately above the generator, on which is mounted the main regulating solenoid with the field carbon pile automatic switch, ampere hour meter and, in the extreme upper right hand corner, a relay which is controlled by the ampere hour meter and which operates to reduce the floating voltage of the system. It will be noticed that the board is hung on hinges so that it can be swung out from the wall when it is desired to inspect the wiring on the back.

By adjusting a resistance in the field circuit of the bucker motor, the generator speed can be varied at will from the low cutting-in speed to over 40 miles an hour. The operation of each element of the regulator can therefore be carefully observed.



The Pullman Car Lighting Instruction Equipment at the Sunnyside Yards of the Pennsylvania in New York

As a means of instructing new men, this operating panel is ideal since it shows just what happens at each step in the operation of the equipment, such as the building up of the generator, the cutting in of the automatic switch, the raising of the plunger of the series coil, the opening of the carbon pile when maintaining the generator voltage constant, and the operation of the ampere hour meter when coming to a state of full charge. The closing of the zero contact in the meter operates the stop charge relay which in turn cuts out a segment of resistance in the main solenoid voltage coil causing the plunger to rise a little higher and regulate at a lower voltage. On decrease in generator speed the automatic switch can be made to drop out in the ordinary way and as the generator voltage goes still lower it will be seen that the armature of the stop charge relay also drops out. The equipment is then ready for normal operation and will pick up in the ordinary way.

Practical Stunts

Convenient Location for a Turntable Motor

When installing a motor-driven turntable for the new engine facilities at Centralia, Wash., the writer's attention was called to the fact that due to heavy rains in that locality and also because the turntable pit was located on a low piece of ground near a river supplied by various mountain streams, it would not be surprising to have the pit fill up with water every spring when the snows on the mountain started to melt. As at that time all turntable tractors were furnished by the manufacturer with the motor located low, underneath the floor of the tractor cab, the effect of a flooded pit was appreciated. It was, therefore, necessary to devise some means of relocating the motor in such a position that when the pit became flooded, the water would not reach the motor. The writer finally worked out the scheme illustrated in Figs. 1 and 2. By referring to Fig. 1 it will be noted that the tractor frame extends a considerable distance to the rear of the motor cab and offers a convenient place on which to locate the motor. It will also be seen from Fig. 2 that by simply turning the motor around and locating it on a base built on the tractor frame outside of the cab, it is still possible for the motor pinion to engage with the top of the gear with which it meshed while located in its original position under the cab. It was, therefore, a simple matter to construct a base for the motor on the part of the tractor frame above mentioned by using I-beams and a plate of sheet steel. It was also necessary to construct a housing for the motor to protect it from the weather, and the details of the housing finally decided on are shown in Fig. 2.

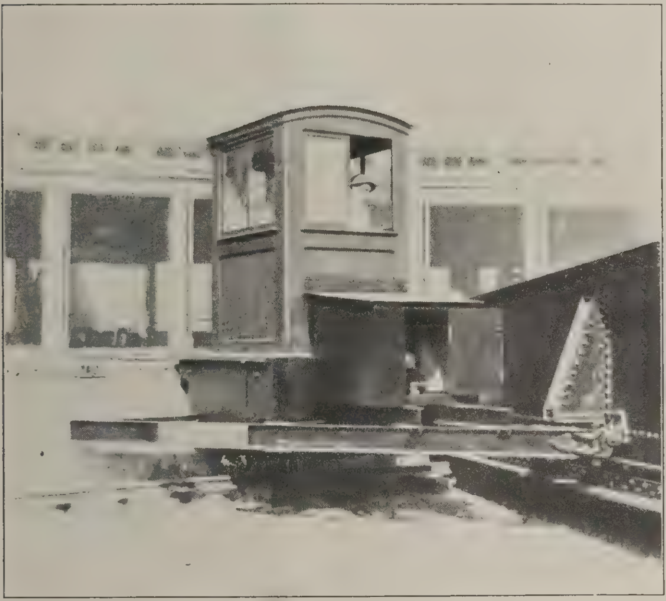


Fig. 1—Illustration Showing Appearance of Motor in Its Present Position

This new location for the turntable motor proved so convenient that the same application, as shown in Fig. 2, has been made standard on the Northern Pacific and not only are all new turntable motors located according to that standard, but some of the old ones have also been so relocated. The main advantages of the new location of the tractor motor are that it is easy to inspect and repair, that it can readily be removed in case it is desired to replace it with another motor and it cannot get wet if the turntable pit should become full of water. The increased accessibility of the motor is very important because there is no question but what a motor that is easy to get at will receive more frequent and careful attention than one that is extremely difficult to get at as were the motors in the old location.

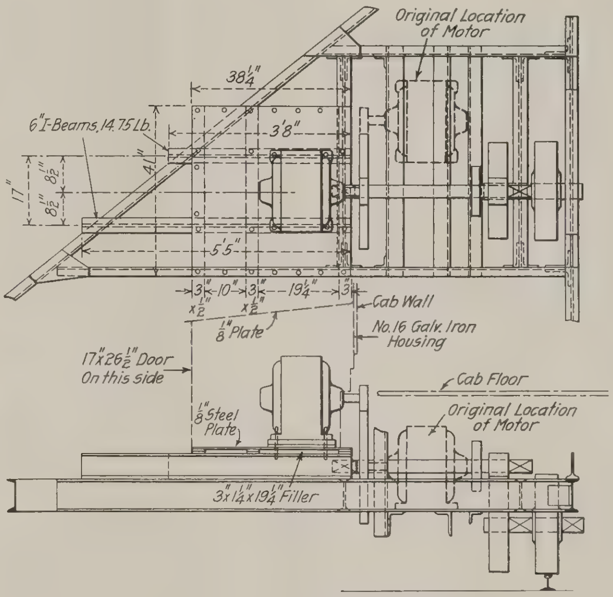

Original Location of Motor
38 1/4"
6" I-Beams, 14.75 Lb.
3'8"
41"
17"
8 1/2"
8 1/2"
5'5"
3" x 1/2"
10"
3" x 1/2"
19 1/4"
3"
Cab Wall
1/8" Plate
No. 16 Galv. Iron Housing
17" x 26 1/2" Door On this side
Cab Floor
1/8" Steel Plate
Original Location of Motor
3" x 1 1/4" x 19 1/4" Filler

Fig. 2—Details of the Motor Foundation Constructed to Permit Relocating the Motor in a Higher and More Accessible Position. Note Its Original Location Under the Cab Floor.

F. W. Reed, Chief Electrician,
Northern Pacific,
St. Paul, Minn.

Annunciator Rheostat

Having had in use for several years an annunciator signal between two departments of the shop, and on account of the unreliability of common batteries for this service, I devised the following scheme which has proven a success and a money saver. To begin with, I have a common "Gravity Drop" annunciator, also our own electric power plant 220 volts, D. C.

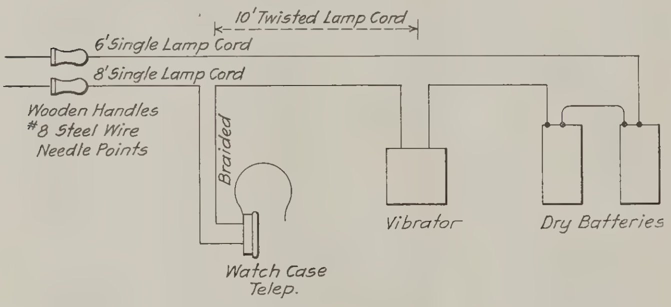
The resistance is constructed as follows: Take a common battery jar of about 6 qts. capacity (about 8 in. across top) and make lid (or cover) for it of hard wood, which should be soaked in shellac and allowed to dry. Then through this cover bore two ½-in. holes 6 in. apart to admit two arc lamp carbons. Over the top of these carbons press a brass cap taken from a ½-in. fuse cartridge, to which is soldered a short wire. When this jar was made I connected it in series with our lighting circuit (220V) and the annunciator circuit (having removed the batteries) and then poured water into the jar, a little at a time until I received the proper amount of current. The jar was connected in the positive side of the circuit, and in this case the carbons are submerged about 4 in. This rheostat has given satisfactory service daily for five months.

J. A. Burris, Electrician,
C. H. & D. Ry., Lima, O.

A Universal Detector

The above name has been given to the outfit herein described, because it has been found reliable in testing for faults in electric machines, and of special value in noisy machine rooms. As shown in the sketch, all that is needed is two ordinary dry cells, a vibrator or buzzer, a watch-case telephone receiver, about 15 or 20 ft. of common lamp cord, and two small handles with steel points for "feelers." The wiring scheme is "series."

The faintest vibration is easily heard even in a noisy boiler shop and any handy man can do as I have done. Finding a magneto unhandy to use without an assistant, I devised the outfit described and have not desired any other for this purpose. The receiver is one from an old telephone and is equipped with a spring to fit over the head. I took the platinum tipped contact points to make a sensitive blade for the vibrator. Two bell-ringing coils (any coil of No. 24 or 36 wire 1 in. diameter 2½ in. long will do) and a piece of ⅛ in. boiler plate (for base) made what proved to be a very sensitive instrument similar to a "buzzer." The whole is contained in a wood case with sliding lid, 3½ in. by 9 in. by 12 in.



J. O. Burris, Electrician,
C. H. & D. Ry., Lima, O.

Emergency Battery Connection

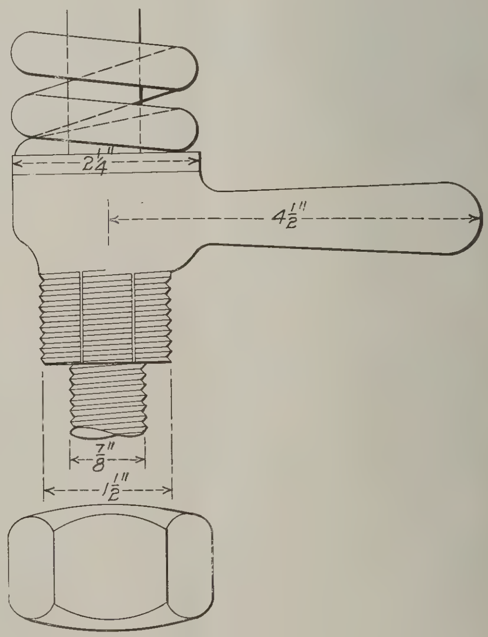
When flushing electric storage batteries, or when pulling them out of the battery box for inspection, etc., it often happens that the tray rolls or slips out towards the front faster than expected, in which case some of the lead posts may become badly bent or broken. As the part of the post which remains after the top has been broken off is too short for drilling a new hole for the connector bolt and also because it is usually inconvenient to replace the damaged cell or tray of cells, it is necessary to provide a good temporary connection for the cable in some other way. In such emergencies the writer has used a scheme which has been found practical and satisfactory. Unfortunately the majority of our shops and repair stations are not equipped with a lead burning outfit which would be necessary to replace the broken part of the battery post, so we make temporary repairs as follows: With a large flat file or rasp the top of the broken battery post is dressed down until it is even with the cover if necessary. A hole is then drilled straight down into the post for about one inch with a 3/16-in. drill. Next we take the connecting bolt, force it into the 3/16-in. hole previously made in the battery post. The bolt is turned into the hole by using a wrench on the nut, the threads easily cutting into the lead of the battery post. The lug on the connector cable is placed flat on the battery post before the bolt is screwed in so that when the bolt is screwed up tight, the connection is made. The writer knows by his own experience that this emergency method makes a good contact both mechanically and electrically.

Henry K. Bohlen,
Pullman Company, Charleston, S. C.

An Improved Tension Nut

In a great many instances we are confronted with machines coming in off the road with loose belts, sometimes due to the fact that the tension nut has worked itself loose, which often causes belt to flange or even to become lost.

The illustration shows a tension nut that I believe will prevent further trouble in this direction.



It will be noted that after the hexagon nut is slipped over tension rod and screwed onto the slotted and threaded section, the tighter it is screwed up the more firmly the tension nut is held in place.

Robt. H. Little, Electrician,
Michigan Central Railroad.

General News Section

The R. & J. Dick Company, Inc., Passaic, N. J., opened on October 1 a branch office at Atlanta, Ga. This is the second new branch opened this year, as they established an office in Seattle, Wash., in January, 1916.

The Electrical Committee of the National Fire Protection Association will hold its biennial meeting in New York city, in March, 1917. A revision of the national electrical code will be considered at this meeting, the exact date of which will be announced later. F. E. Cabot, of Boston, is chairman of the committee, and Ralph Sweetland, 141 Milk street, Boston, Mass., is secretary.

The system of propulsion being installed on the "Tennessee," a U. S. super-dreadnaught of the largest and finest class, differs from any now in use by battleships. Instead of the propellers being mechanically connected to the driving engines or turbines, there are two steam turbines developing over 33,000 h.p. driving electric generators which furnish current to motors.—*Journal of Electricity, Power and Gas.*

St. Paul Electrified 336 Miles

The Chicago, Milwaukee & St. Paul, on November 1, put in operation its third electrified district; the line from Deer Lodge, Mont., to Alberton, 110 miles. This makes the total length of line electrified, Harlowton to Alberton, 336 miles. The last district to be electrified, that from Alberton to Avery, is expected to be put in operation in January. With the completion of this section the total electrified mileage will be 440.

U. S. Light & Heat Corporation

At the recent annual meeting of the stockholders of the United States Light & Heat Corporation the following Board of Directors were elected: Egbert H. Gold, J. Allan Smith, Ralph C. Caples, Henry W. Farnum, A. Henry Ackermann, Chauncey L. Lane, Keene H. Addington, James A. Roberts, Conrad Hubert, George G. Shepard, Edwin K. Gordon. An attempt was made to obtain proxies for an opposition ticket, but at the meeting no such ticket was presented. The vote of confidence in favor of the present management was 371,079 out of 425,245 votes cast.

The Little Yellow Dog

The Order of Yellow Dogs which was started three years ago at the Chicago convention of the Association of Railway Electrical Engineers is growing rapidly, and this year many new members were initiated at convention headquarters. The order was founded by Barney Gallagher of the Illinois Central, and true to its name it was only necessary to give it a good start. This year the Kerite company presented a button to new members, as did the Harter Manufacturing Company which also provided a register suitably engraved with the name of the order.

Great Northern to Electrify.

It is reported that the Great Northern is making extensive plans for the electrification of about 300 miles of its main line between Spokane, Wash., and Seattle. The power for running the electric locomotives will be supplied from hydro-electric stations probably located on the Chelan river. The problem of furnishing sufficient electric power for operating the trains over the heavy mountain grades on this section of the Great Northern involves the raising of the level of Lake Chelan so as to provide a greater head for the power plants and also to provide sufficient water storage capacity. Ralph Budd, assistant to L. W. Hill, president of the Great Northern, has announced that the company is working on the plans of the electrification but it does not intend to start work on the project immediately as considerable time will be required to work out the details. The heavy mountain grades and the dense traffic on the 300 mile section of the Great Northern west of Spokane are the main reasons for the decision to electrify. In the opinion of the railroad officers, electrification is the only satisfactory solution to the problem.

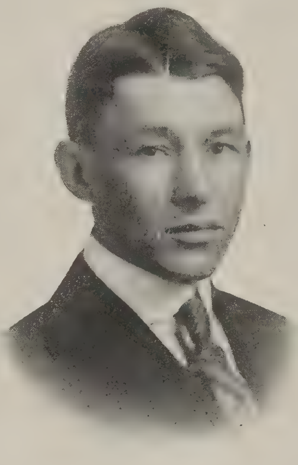
Status of Electric Operation on the New Haven

Some information regarding proposed new equipment on the electrified zone of the New York, New Haven & Hartford was given out at an investigation of the passenger train service of that road, held by the Massachusetts Public Service Commission at Boston, October 17. Howard Elliott, president of the company, stated that specifications are now being drawn up for 60 additional electric locomotives for passenger, freight and switching service between New York and New Haven. He said that until the road was in better financial condition, nothing would be done in the direction of electrification at Boston, also that the company is not considering the extension of electric service beyond New Haven. A. R. Whaley, vice-president, said that the New Haven would require 70 additional electric locomotives to handle the entire traffic, passenger and freight, electrically, throughout the electrified zone between New York and New Haven. At present only partial electrical service is carried on between Stamford, Conn., and New Haven. The company has now about 100 electric locomotives.

According to Mr. Elliott, electric locomotives cost at least $50,000 each. The cost of steam locomotives has risen from $28,000 to $42,000 in the past three years. The company can not yet say when it will have 100 per cent electrical operation in the New York-New Haven zone.

Personals

Louis Sears has been appointed manager of railway sales of the Willard Storage Battery Company, succeeding the late W. E. Ballantine, whose death was announced in the January issue of the *Railway Electrical Engineer*. Mr. Sears has been with the Willard Storage Battery Company since April, 1908, remaining at the factory until January, 1910, at which time he went to the Chicago office where he remained until October, 1913. He was in the Cleveland office October, 1913, to March, 1915, and from March, 1915, to August, 1916, he was located in the New York office. Mr. Sears was transferred to the Cleveland office and appointed manager of railway sales on August 1, 1916.



G. E. Goldthwait

G. E. Goldthwait has been appointed associate editor of the *Railway Electrical Engineer*. Mr. Goldthwait was born in 1889 at Marion, Ind., where he attended grade and high school. He then entered Purdue University and was graduated in 1911 from the school of Electrical Engineering. After working a short time on some special tests for the Commonwealth Edison Company of Chicago, he entered the employ of the Westinghouse Electric & Manufacturing Company on its graduate student course, specializing in shop and test work on railway apparatus. He left the Westinghouse company in November, 1912, to go with the Pittsburgh Railways Company, where he was load despatcher and assistant to the electrical engineer. When the Norfolk & Western was equipping its Elkhorn grade for electrical operation, Mr. Goldthwait took advantage of an opportunity to get into railroad electrification work and entered the employ of Gibbs and Hill on construction work in October, 1914. He was later transferred to the Norfolk & Western as power director at the Bluestone power station when the railway company started to operate its electrified section early in 1915. He remained with the Norfolk & Western in this capacity until June 30, 1916, after which he went with the Standard Steel Works Company, at Burnham, Pa., in connection with electrical construction work. He left Burnham on November 1, 1916, to accept his present position with the Railway Electrical Engineer.

William Ward Hincher, Chicago manager of Albert & J. M. Anderson Manufacturing Company, with Mrs. Hincher was instantly killed in an automobile accident on October 18, near Shelby, Ind. Mr. and Mrs. Hincher had left Chicago early that morning and were en route to the convention of the Jovian Order at Indianapolis when the tragedy occurred. The news of the accident came as a great shock to his many friends who were already in Indianapolis and also to those in Chicago and elsewhere where he is highly esteemed. Mr. Hincher was born on July 18, 1876, at Burr Oak, Mich., and for a number of years resided in Muskegon and Sturgis, Mich., respectively. He moved to Chicago on December 26, 1898, and at that time married Miss Marie I. Kirlin. Mr. Hincher became connected with the Chicago City Railway Company on his arrival in Chicago and at the same time attended night school at Lewis Institute. Later he accepted a position with the Anderson company and remained as its representative until the time of his death. Mr. Hincher was active in many clubs and organizations in Chicago and of national character, and was high in Masonic circles.

C. L. Lane, who has been secretary of the U. S. Light & Heat Corporation, Niagara Falls, N. Y., has been elected vice-president of this company at a recent meeting of the Board of Directors.

Railway Structures

The St. Louis & San Francisco has commenced the erection of a one-story brick and concrete roundhouse at Chouteau avenue, St. Louis, Mo. The building will cost about $25,000, and the contract was awarded to James Stewart & Co., St. Louis.

The Atchison, Topeka & Santa Fe has awarded a contract to the Roberts & Schaefer Company, Chicago, for building a 400-ton, four-track, automatic electric coaling plant, using the duplex shallow pit loader, at the new terminal at Las Vegas, N. M. Contract price, $22,000.

The Kansas City Terminal, of Kansas City, Kan., will make terminal improvements at an approximate total cost of $4,000,000. The project includes the erection of two $100,000 passenger stations, two freight stations and a long double-track steel viaduct. About five miles of new track will be laid. The work will involve the use of 17,000 tons of steel and 40,000 cu. yd. of masonry.

Trade Publications

Pole Sleeves.—Drew Electric & Manufacturing Company, Indianapolis, Ind., has issued a circular describing and giving directions for installation of their protective and reclaiming pole sleeves which have found extensive application in protecting steel poles from corrosion at the ground line.

Lighting Fixtures.—The Central Electric Company of Chicago manufactures a complete line of fixtures and reflectors for industrial lighting known as Maxolites for use in shops, freight sheds, warehouses, yards, etc. Maxolites are described in Bulletin No. 60, issued by this company.

Electric Machine Tools.—The Hisey-Wolf Machine Company, Cincinnati, Ohio, has for distribution a new set of bulletins describing Hisey portable electric machine tools. These bulletins supersede previous publications on the same subject.

Some Graphical Solutions of Electric Railway Problems is the title of bulletin No. 90, issued by the Engineering Experiment Station of the University of Illinois. The booklet presents an extended discussion of motor characteristics and speed-time curves. A. M. Buck is the author.

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The Situation at Washington

President Wilson in his message to Congress insists that action be taken looking toward the enlargement of the Interstate Commerce Commission; that provision should be made to prevent strikes or lockouts until arbitration had been resorted to; and also that the chief executive should have the power, in case of military necessity, to take control of the railroads and rolling stock or such portions of them as might be necessary, for military purposes.

Meanwhile a test case as to the constitutionality of the Adamson eight-hour law has been rushed to the Supreme Court. It will not hear the arguments until after the first of the year, and by agreement between the railroads and government representatives, the law will not be enforced until a decision is handed down.

In addition to all this, the Newlands or Congressional Joint Committee on Interstate Commerce opened hearings on November 20 with a view to investigating the entire problem of railway and public utility regulation. Briefly, the railroads are in favor of a fair and stable system of regulation and to secure it they advocate that the entire power and duty of regulation should be placed in the hands of the national government, except for local or incidental questions that can be more easily handled by state authorities. An enlargement of the Interstate Commerce Commission is recommended, as well as the creation of a new federal railroad commission and regional commissions in order that prompt attention may be given to all questions which may arise in connection with railroad rates and regulation. This would make it possible for the commission to confine the suspension of rates to 60 days from the time the tariffs are filed instead of 10 months as at present. The federal incorporation of railways is also advocated, as well as giving the federal government exclusive power to supervise the issuance of securities by interstate carriers.

With all of the above mentioned agencies at work upon the railroad problem the next few months promise to be critical ones in the history of railroading.

Swiss Railway Electrification

The electrification of 67 miles of the St. Gothard line of the Swiss State Railways, now in progress, is the first step in a project ultimately to operate all the federal-owned lines in that country, aggregating nearly 2,000 miles, by electric power. The single-phase a. c. system, as is now operating on the Lötschberg line, is to be used on this and future electrifications, the commission in charge having decided that it is the only system worthy of serious consideration for a project of such magnitude. While all the usual benefits are expected to accrue from the improvement, the principal item is the economy of utilizing the immense water power resources of the Alps, thereby making the railroads independent of expensive imported fuel, there being no coal mined in Switzerland.

The development should be watched with interest by American engineers, as there will be no doubt many lessons to be learned applying to similar work in this country. European and American railroad practices differ widely in many respects, though probably the only essential wide difference is in the limitation in power and weight of locomotives imposed by European conditions. There has apparently been however very little interchange of ideas or inventive co-operation between the engineers of the Old and New Worlds, and this condition does not reflect much credit on either. The decision to use single-phase in Sweden, Germany and Switzerland, to the rigid exclusion of other methods, ignores completely the successful development and application of high-voltage d. c. in this country; and in some American circles the importance of the decision of European engineers is equally unheeded. The "Battle of the Systems" has been going on for about ten years, and with the limit of development of neither in sight, we are as far from a decision as at the start. Since both a. c. and d. c. have been applied with great success to all forms of electrification problems, a choice must be based largely on an opinion of what the future holds.

Arc Welding for Steam Railroad Repair Shops

Although arc welding as an agent for repair work is a comparatively recent development, it has already fully justified its existence in the steam railroad field, and the next few years will see a far greater extension of this class of work than has yet taken place.

The rapidly increasing use of electric arc welding equipment in the steam railroad field makes it well worth the while of every one interested in the electrical department of the steam railroads to become thoroughly familiar not only with the process itself, but with the various types of equipment which are on the market. There can usually be found installations of arc welding equipment at some point nearby, giving opportunity for obtaining first hand information.

One of the chief reasons for the rapid advancement of the arc welding process has been its great adaptability to all classes of repairs. For example, widely differing classes of work, such as welding a broken locomotive frame, reclaiming a worn coupler or repairing a flat wheel, can be done with equal facility and economy. So broad is the field of this process that there is hardly a piece of wrought iron or steel used in locomotive or car construction that cannot be repaired or reclaimed more economically by arc welding than by other means, provided its repair or reclamation is at all practicable.

Although the argument usually advanced in favor of electric arc welding, as compared with other methods of repair, is that of economy, there are other considerations fully as important which merit careful consideration. For example, in work such as welding of flues to back flue sheets in locomotive fireboxes it has been found that the electric arc is the only welding process which will give satisfactory results. This has been adopted as standard practice by a number of the railroad systems of the country and, although some troubles have been encountered, these troubles have been usually traceable to defective methods of application rather than to the process itself.

Another factor meriting careful consideration is that of economy of time. An analysis of data available has shown that the gross earning power of a steam locomotive will average about one hundred dollars per day, and it is, therefore, obvious that anything that can be done to shorten the length of time required to put a locomotive through the shops is of tremendous value. This is especially true under business conditions as they exist in this country today, where maximum transportation capacity is a universal demand.

One of the best examples of economy of time is in the repairing of flat wheels, mentioned in an article appearing in another part of this issue. A locomotive driving wheel with a flat spot can be repaired by welding, by simply building on metal at the flat spot, then filing down to shape by the use of a template. The locomotive can be put back in service in a few hours at a purely nominal expense. If welding were not used it would be necessary to unwheel the locomotive and turn the entire set of driving wheels, thereby shortening the life of the tires by about 10,000 miles and keeping the locomotive out of service for at least three or four days. When, in addition to the actual expense in making the repair by the old method, the indirect expense in loss of earning capacity is considered, the true value of welding equipment is obvious.

Where arc welding equipment is being first used, it should be remembered that it is unfair to the operator or to the equipment to expect 100 per cent results on all classes of work before the operator has gained the necessary experience. It would not be expected that a farmhand could be turned into a competent blacksmith by instruction covering a week or ten days, yet this, and more, is often expected in the case of arc welding operators. It is nearly always desirable to train welders from the ranks of shop crafts. For instance, for general locomotive repair work it is wise to take, as raw material for welders, men who have had previous experience as boilermakers or blacksmiths, as their knowledge will stand them in good stead in their new work. These men then should be given careful instruction under the supervision of a competent demonstrator from the manufacturer of the equipment or under that of an instructor from the shop welding corps. They should also be followed closely at all times to see that they are going through the correct procedure and using right methods, as in no process has the personal element greater weight.

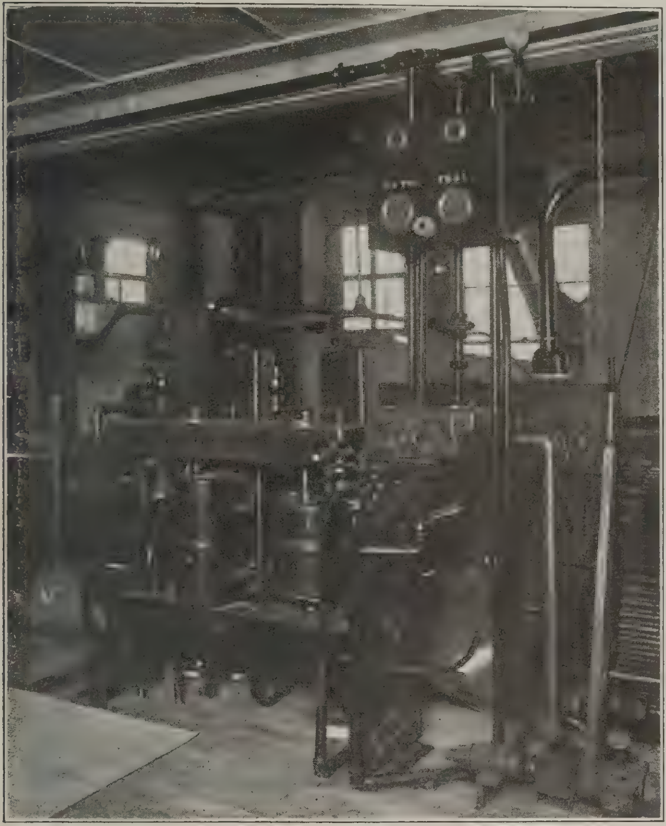
Electric Traction Calculations

There are many refinements in engineering work made possible when electric traction is substituted for steam. One of the most notable of these is the ability to calculate accurately, from nothing but design data, the speed, acceleration, power required and size of equipment necessary to handle a given service. The most important factor in such calculations is the characteristic curve of the railway motor, which is used to develop a speed time curve for the determination of schedules, etc. The method used is the same throughout the range of electric traction, whether it be for a street car on city tracks or a high speed passenger train pulled by an electric locomotive.

Such calculation methods are standardized to some extent; however, they are not matters of general information even among electrical engineers. It is therefore particularly appropriate that we have found the opportunity of presenting information on this subject in a series of articles on electric traction calculations, beginning in this issue. In view of the number of electrification projects now under discussion, it is important that railway electrical engineers keep themselves well informed on the technical aspects of the subject.

Electrically Operated Bridge on the North Western

THE Chicago & North Western has recently placed in operation, at the Deering crossing of the north branch of the Chicago river, a three-track Strauss trunnion bascule bridge. The clear width of channel at this point is 145 feet, but the bridge, being built on a skew of 17 degrees, is 180 feet long. There were 2,441,246 lb. of steel used in its construction exclusive of the counterweight, which weighs 2,359,825 lb.; weight of moving span, 1,309,000 lb. The bridge is normally operated by electric motors, but a gasoline engine is available for emergency service.



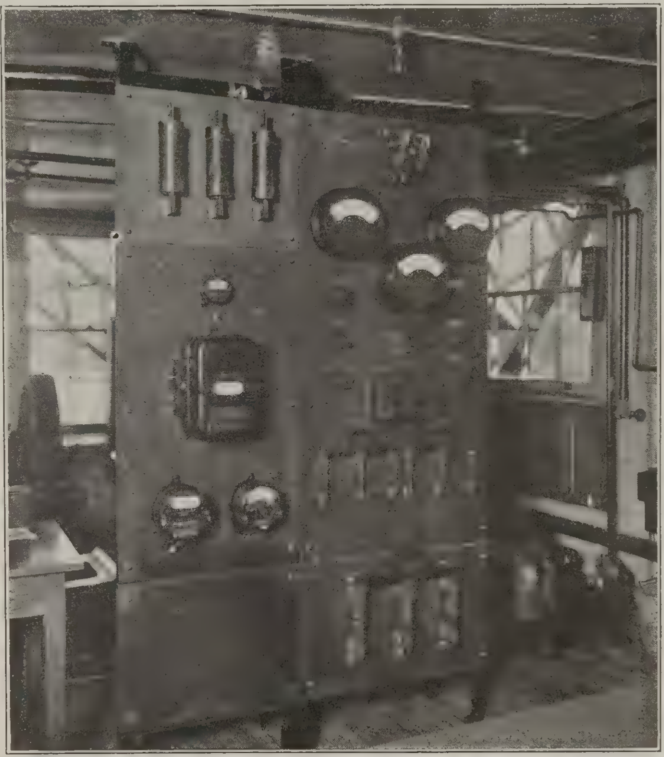
Motor Control and Interlock Apparatus

Electrical Equipment

Power for regular operation of the bridge is purchased from the Commonwealth Edison Co. The service transformers, installed by the power company, consist of three 50 kw. each, single phase, 3,300 to 440 volts. From the low tension side of the transformers the current is brought directly to fuses on the switchboard in the operating room. The max-meters and wattmeters are mounted on the same panel with the main fuses. The distributing panel adjoins the service panel and contains distributing switches, ammeter, voltmeter and indicating wattmeter.

The two main motors are each 150 h. p., 440 volt three phase, 60 cycle Westinghouse wound-rotor type. Each motor is equipped with a substantial solenoid brake adjusted for braking equal to the normal running torque of the motors. The motor operating the lock on the front end of the bridge is a 5 h. p. high resistance squirrel cage type.

Cutler-Hammer magnet type control is used, consisting of four reversing and five accelerating contractors for each main motor. Both lock motor and main lifting motors are controlled through limit switches at the ends of their respective travels. The main line contactors for the lifting motors are tripped out when the moving span is within 15 degrees of the fully closed position; to close it the remaining distance a foot switch is provided for releasing the brakes and a push switch for short-circuiting the limit switch and thus closing the contactors. The motors may then be started by the master controller.



Distributing and Meter Panels

The master controller is interlocked with the lock motor in such a way that neither lock nor main motors can be operated out of proper sequence. The operation of the lock and main motors is in turn interlocked with the signal machine. To open the bridge, all track warning signals must be set to "Danger" before motor controllers can be released.

Under normal conditions, the bridge requires 450 amperes to start, dropping to 250 amperes running current. The time required for a complete opening is one and one-half minutes.

Auxiliary Power

Probably the most unusual feature of the installation is the provision for emergency power. The bridge is normally operated by the electric motors, but government engineers require two independent sources of power to insure continuity of service over a navigable stream of such importance as this one. The reliability of central station service, however, is such that the installation of an expensive power plant is not justified.

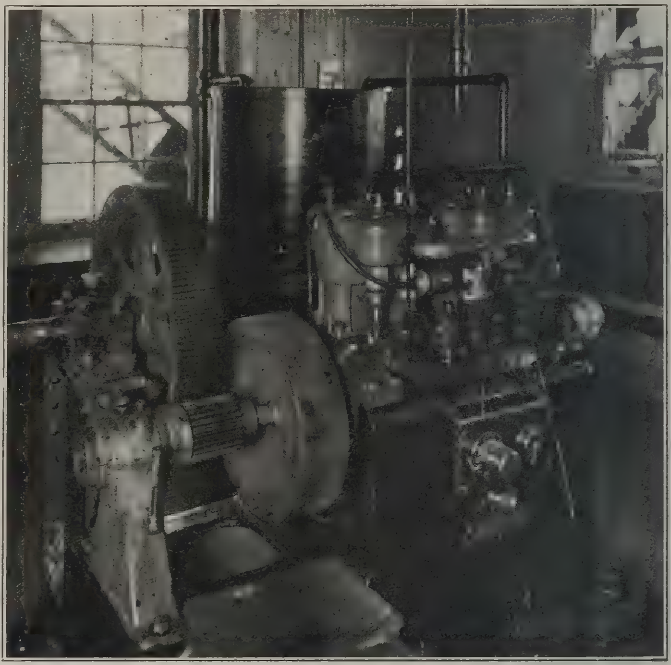
A four-cylinder automobile engine, made by the Wisconsin Motor Manufacturing Co., is used for the purpose, connected to the machinery by a slip gear and friction clutch. It has 4¾ by 5½ inch cylinders, 45 h. p. rating, and is controlled by a governor set to allow a maximum speed of 1,200 r. p. m. The engine is light, well balanced, easily started and regulated, being handled very much the same as an automobile. The operator starts the engine by cranking, goes over to the clutch wheel where are located the throttle and spark levers, throws in the clutch gradually when the engine is up to speed, at the same time opening the throttle to admit more gasoline. On a test of the auxiliary power, the slip gear for the engine was thrown in mesh with the main machinery drive, the engine started, and the bridge raised to an angle of 45 degrees, all in ten minutes.

Service Connections and Transformers

Signals

The system of warning and indicating signals on this bridge is most complete. In addition to the usual channel warning lights required by the goevrnment, a wig-wag warning to river traffic has been introduced as a signal to vessels in event of a failure of bridge motive power. The wig-wags are located in the center of the bridge on the lower chord where they can easily be seen from the river; they are controlled by snap switches in the controller stand. Directly in front of this stand is a signal box with a lamp and semaphore to each wig-wag motor. The lamp burns and the semaphore goes to "Clear" when the wig-wag is operating. In the event of failure the semaphore goes to "Danger" and the lamp is extinguished.

Air at 100 lb. pressure is supplied to the strut brake and warning whistle, from two 25 cubic foot storage tanks suspended from the ceiling of the operating house. A General Electric motor driven air compressor, 25 cubic feet capacity, pumps air into the tanks, controlled by an automatic governor.



Auxiliary Gasoline Engine

The operating machinery is on the fixed part of the bridge, located in a machinery room above the tracks. The room contains gearing, motors, engine, air and water tanks, switchboard, controllers, interlocking stand and all other operating devices.

The bridge, designed by the Strauss Bascule Bridge Co., was installed under the direction of W. H. Finley, chief engineer, H. M. Spahr, assistant engineer directly supervising the work. The foundations were installed by the Great Lakes Dredge & Dock Co., which also removed the old swing span. The bridge was fabricated by the American Bridge Co., and erected by the Kelly-Atkinson Construction Co.

C. H. Norwood of Chicago furnished and installed all air and electrical equipment and the auxiliary gas engine drive. Mr. Norwood supplied the information and photographs used in this article.

RUBBER INSULATION OF WIRE.—Numerous tests have been made by the United States Bureau of Standards in connection with an investigation to determine the effect of dry heat on the physical properties of the rubber insulation of wire. This work is being carried out in collaboration with the testing department of the Pennsylvania Railroad and other laboratories identified with the American Society for Testing Materials, the object being to develop an accelerated test for insulated wire that will indicate the probable life of the wire insulation under normal service conditions.

ELECTRIC WELDING IN RAILROAD SHOPS

The Field for Arc Welding Is Extensive and Its Usefulness Just Beginning to Be Appreciated

BY GORDON FOX

Welding a Broken Locomotive Side Frame by the Metal Electrode Process

ELECTRIC arc welding is a form of autogenous welding, which may be defined as a welding process in which the metals are raised to such a temperature that they will fuse together without the application of pressure. The principle forms of autogenous welding are oxy-acetylene welding and arc welding. There is nothing mysterious about the use of electricity for welding, as its function is simply to produce heat, that being the sole reason for its use. In electric arc welding one terminal of a source of direct current is connected to the piece to be welded, the other terminal being an electrode in the hand of the operator. The movable electrode is touched to the article, establishing the flow of current. The arc is drawn by withdrawing the electrode a short distance. If this separation is maintained within moderate limits the arc will continue to flow between the electrode and the object and the heat of this arc fuses the metal at the point of welding. This metal unites with that adjacent to it and, upon cooling, forms a solid body.

The two methods of arc welding in common use are the Bernardos or carbon electrode process, and the Slavianoff or metallic electrode process.

Bernardos Method

In the Benardos method the electrode manipulated by the operator is a carbon pencil which varies from ½ in. to 1½ in. in diameter and from 6 in. to 12 in. in length. The size of the pencil used is varied to suit the nature of the work. Special pencils for arc welding may be secured from carbon manufacturers, they being preferably of graphitic carbon which has high thermal and electrical conductivities. The carbons should be uncored. Long pencils are generally clamped near the working end in order to shorten the current path and reduce the internal resistance; as they wear away the clamping position is changed. The pencil should be ground to a point and should be maintained fairly sharp in order that the position of the arc may be controlled. With round ends the arc has a tendency to travel, especially if there be any movement of air. The carbon is clamped in a light weight, insulated holder having a shield in front of the handle to protect the operator from the excessive heat.

The arc welding process involves the heating of the object to the proper degree, followed by the feeding in of molten metal of proper characteristics to join the parts, to fill the holes or to build up the surface, as desired. This filling material is usually introduced by melting the so-called filler rod under the arc. For wrought iron or steel, various filling materials ordinarily Norway and Swedish iron may be used. Bits of steel castings, boiler iron or scrap are sometimes used in place of filler rods. For cast iron, either of the above rods may be used or iron wire or special cast iron filler rods high in silicon may be best suited. A high percentage of silicon in the filler rod tends to give soft metal at the weld. The filler bar should be ⅛ in. to ½ in. in diameter, depending upon the nature of the work. Rods of ¼ in. diameter are good for average jobs, and those about 3 ft. in length are as long as can be conveniently manipulated. Short rods and small bits are harder to use since they cannot be readily seen by the operator.

Use of Flux

The use of a flux is somewhat optional. The purpose of a flux is to protect the surfaces from oxidation, and some welders are emphatic believers in it, while others see no benefit from its use. Practice is not standardized in this respect. It is hardly necessary to use a flux when welding wrought iron or steel, but when welding cast iron the use of a flux may be generally recommended. Borax makes a good flux to which may be added about 20 per cent of red iron oxide. Many commercial fluxes are obtainable, and all may be used either dry or wet. The most satisfactory results are obtained by mixing the flux into a paste, using water, and coating the filler rods with this paste. Filler rods may be purchased in this form also. As such rods melt the flux is introduced automatically.

Preheating and Annealing

The arc welder who has any large volume of work to perform, particularly upon cast iron, should be provided with a suitable preheating and annealing furnace which may be heated by oil, gas or charcoal. Its use is almost imperative for many jobs on cast iron. Aside from the furnace, some fire bricks, fire clay and asbestos for molding and damming, a wire brush for removing scale and a machine hammer for peining the new metal complete the list of equipment required.

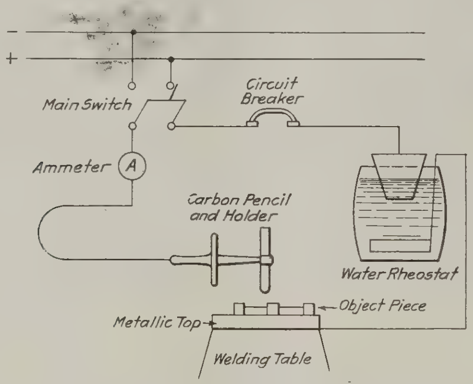


Fig. 1—Diagram Showing Use of a Water Barrel Resistance When Welding with Voltages Above 110 Volts

Current Used

The electric power must always be direct current. For carbon electrode work, about 35 to 50 volts is required across the arc, the exact amount varying with different classes of work and different arc lengths used by the operator. It must be possible to short circuit the arc without causing too severe a rush of current in the feeder circuit. In the Benardos process the current required depends upon the nature of the work, amounting to about 300 to 400 amperes for average service. Thus about 15 to 20 kw. of heat is liberated at the arc for heating the metal.

Use of Resistance

If power is taken from 110 volt or 220 volt or even 550 volt power lines, resistance may be inserted in series with the arc to reduce the voltage to the desired value. This resistance serves a double purpose in that it cuts down the arc voltage and, at the same time, prevents a heavy short circuit current when the electrode is held in contact with the object previous to drawing the arc. Water barrels or rheostats may be used for this purpose, as shown in Fig. 1. Grid resistances are superior to water barrels in that they are more portable and may be worked hard without giving trouble such as is experienced due to boiling over of water rheostats. For the occasional job, however, the water rheostat is as satisfactory as the expensive motor generator set, except that with its use the cost for current is greater. The wiring diagram in Fig. 2 shows the connections of a welding outfit using grid resistances.

Motor Generator Sets

If alternating current alone is available, a motor generator set is a necessity. Such a set is also of value where the direct current is at 115 volts or higher and where a considerable volume of work is handled, as there is considerable power lost in reducing the voltage from 230 to 50 volts by resistance. The purpose of a motor generator set is to transform the available power and deliver it in the form best suited for the welding. In a straight direct current set the only object is to save power. The justification of the investment depends upon the amount of welding work done, the character of the work, the voltage of the supply and the cost of power.

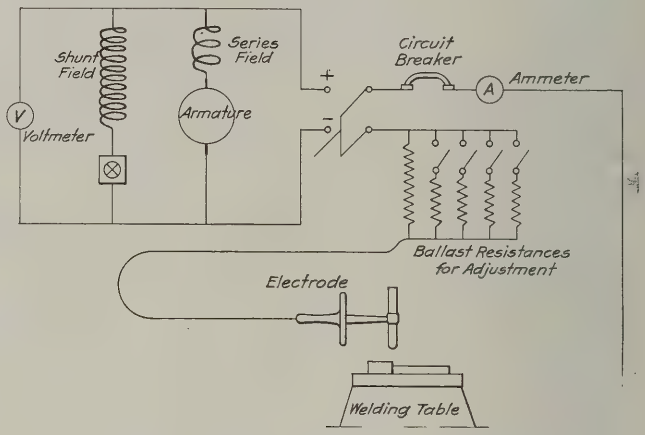


Fig. 2—Diagram Showing the Connections for a Welding Outfit Using Grid Resistances Instead of a Water Barrel

Constant Voltage

Two distinct types of motor generator sets are available for arc welding, different manufacturers championing different systems. In one type the current is delivered at an approximately constant pressure of 60 volts and an adjustable resistance is used in series with the arc to vary the arc voltage to suit the work in hand. The connections for the generator of such a set are shown in Fig. 2. This type of generator is particularly adapted for installations where several welders will work simultaneously. Under such conditions each welder adjusts his arc by means of an individual resistance bank on a small panel furnished for each outlet. Several welders may draw power from the same motor generator set, yet be entirely independent of each other This type of machine does not eliminate all the resistance losses, inasmuch as the reduction from 60 volts to arc voltage is represented by resistance loss. The commercial sets of this type are normally capable of handling a single large carbon arc or several smaller metallic arcs simultaneously.

Constant Current

The second type of motor generator set is a so-called constant current or variable voltage equipment. In this system the generator delivers a variable voltage, maintaining an approximately constant current flow. For instance, when the electrode touches the object in striking the arc, the voltage is nearly zero, and as the electrode is drawn away, the voltage increases with the lengthening of the arc. A machine of this type delivers automatically the desired voltage to maintain an arc of desired intensity. It is therefore effective in affording constancy and uniformity of the arc and, inasmuch as no ballast resistance is required, this system is more efficient than the previous one. Sets of this type are commonly built of proper size to handle a single metallic arc. Obviously, such a set can feed but a single arc since, with more than one outlet, the requirements of two welders would interfere. When carbon arc welding is to be done, two or more sets are paralleled to supply the required capacity.

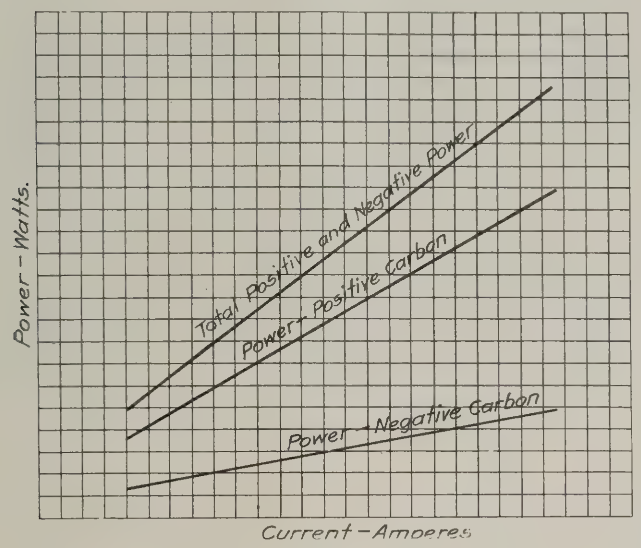


Fig. 3—Curves Showing How the Power Consumed in a Carbon Arc Is Apportioned Between the Positive and Negative Electrodes

Polarity of Working Electrode

In the Benardos process it is necessary that the piece to be welded be connected to the positive side of the system, the manipulated carbon being the negative side. In a direct current arc the greatest energy absorption, therefore the highest temperature, occurs at the positive electrode. This may be explained by the theory that the metallic vapor in the immediate vicinity of the positive electrode is of higher resistance than that near the negative electrode, which is well illustrated by the curves in Fig. 3 showing how the power consumed in a carbon arc is apportioned between the positive and negative electrodes. When the metal to be welded is made the positive electrode, melting should be more rapid, since the greatest heat is developed at the metallic surface. As iron and steel are more readily vaporized than carbon, with the metal the positive terminal, a greater quantity of metallic vapor is carried into the arc. This vapor has greater conductivity than carbon vapor and maintains the arc more steadily. Also, if the carbon were the positive terminal, the arc stream would carry carbon particles and vapor into the weld, making the metal hard and brittle.

Welding with the Carbon Arc

In making a weld with the carbon arc, the piece to be welded is laid upon the metallic welding table in such a way that a good contact is secured. The point of welding should preferably be on top, as it is much more difficult to weld upon the side of an article than upon its top surface. Welding upon the under side of pieces cannot be accomplished by the Benardos method and can be done only after much practice with the Slavianoff method. If a large piece is to be welded it may be more convenient to simply clamp the positive lead to it at some point.

Preparation of work for welding by the carbon arc consists mainly in thoroughly cleaning the surfaces to be welded. In most cases this can be done by turning the work edgewise or inclining it and then going over the surface with the arc and melting off all surface impurities which will run off by gravity thus leaving clean metal. The same procedure can be followed where two pieces are to be joined, the arc being used to melt the edges of the sections to be joined so as to provide a V-shaped groove at their junction, thereby insuring that the entire joint is filled with perfect metal. Where thick sections are to be joined, it will often be found advisable to cut a groove from both sides to the center of the section. In any event it is essential that the groove extend entirely through the junction.

At the beginning of the work the arc must reach the bottom of the groove and liquefy that point first. It is impossible to reach the bottom of a narrow groove since the arc will jump to the sides. A double angle of about 90 deg. is therefore necessary. If a crack is to be repaired, it should first be recessed either by using the arc as just outlined or by chipping a V-shaped groove in it. When two pieces are to be welded together they must be first alined and clamped together or to a third piece. If a one-sided heat is to occur, some allowance must be made for unequal contraction. This part of the work calls for experience. If it is desired to build up new metal to any height, a mold must be made to retain the molten material which may be made of asbestos or fire clay.

The arc used should be one to two inches long, depending on the size of the electrode and nature of the work. It is well to use an ammeter to observe what current is most effective for different kinds of work. The arc is moved with a rotary motion from one side of the piece to the other in order to distribute the heating uniformly over the zone to be welded. When melting temperatures are reached the arc is confined more to the center of the groove and the filler rod is brought into play to start filling in, care being taken to see that the new metal adheres and flows into the metal of the side walls. As new metal is added the groove is filled and the point of action is moved forward. The arc is kept in motion all the time, however, a circular swing being most effective. If flux is used for the work and this is not supplied in the filler rod it may be shaken into the weld from time to time, a can with perforated cover forming a convenient means. As soon as the weld is completed the electrode is laid aside, the hood removed and the new metal giving a thorough peining to make it more dense and improve the grain. The work of welding should, if possible, be done in one continuous heating in order to prevent formation of oxide and for other reasons. A heavy piece may be welded from two sides, in which case each side would be hammered before turning over.

Welding with the Metallic Arc

The metal electrode or Slavianoff process is, in most respects, quite similar to the carbon process. Instead of the carbon pencil a smaller metallic pencil is used which also forms the filler rod; it melts away and enters or builds upon the object as the welding progresses. A lower voltage and shorter arc are used for this method. The arc is only about 1/8 in. to 3/16 in. long, while the voltage at the arc is about 18 to 30 volts. The current used will be about 90 to 200 amperes, according to the size of the pencil and the character of the work. The pencils are from 1/8 in. to 1/4 in. in diameter and about a foot long. A small, light holder is used, being arranged to grip the pencil through a cam or other clamping arrangement, so that new pencils may be quickly inserted as the old ones are consumed.

Preparation of work for welding done by the metal electrode is in most respects similar to that for carbon arc work. For many classes of work, in fact the carbon arc can be used to prepare the work for repair by the use of the metallic arc. The first essential is that of absolute cleanliness of the work, all traces of oil, scale, rust, etc., being thoroughly removed before welding is begun. Where flues are to be welded to flue sheets, in locomotive fireboxes, this cleaning can be very satisfactorily done by use of a sand blast which, if properly used, leaves the flues and sheets in condition for welding without further preparation.

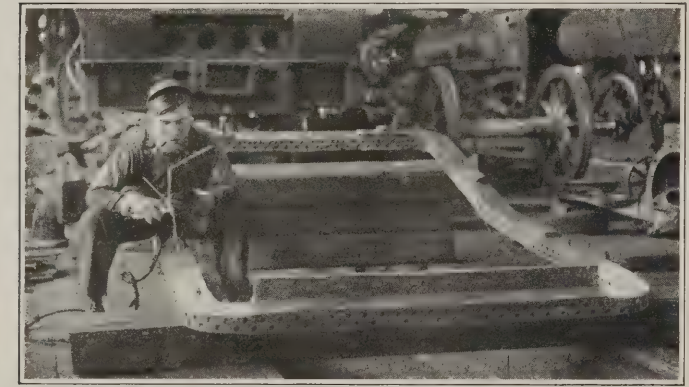


Fig. 4—Building Up the Worn and Corroded Part of a Locomotive Mud Ring by the Metal Electrode Process

Before attempting to repair work such as cracked firebox sheets, broken frames, etc., it is necessary to provide space for the metal to be added, just as is the case with the carbon electrode process. Where a crack is to be repaired the sheet should be cut along the line of the crack, into a V-groove with an angle of about 90 deg., the sheet being cut entirely through and the width at the bottom of the groove being approximately 1-16 to 1/8 in. The cutting may be done either by a chisel or by first using the carbon arc to cut the groove, then using an air chisel to clean up the sides and remove all of the melted surface.

Where welding is to be done in a vertical plane as would be the case where vertical cracks are to be repaired on firebox side sheets, or the vertical sides of a patch in the firebox, the welding should be begun at the bottom of the groove. The metal added is then built up on top of that previously deposited, and with reasonable care sound welds are assured.

In filling in cracks, welding patches, etc., practice differs as to whether to fill the entire groove at one application of the arc or whether to first fill the bottom of the groove and later add enough metal to finish the weld in a second course. Either method should give satisfactory welds providing proper care is taken by the operator to assure a thorough junction between the sheets and the new metal. Where welding is done in one course, care should be taken to see that all particles of oxide or slag are removed from the surface of the preceding course, as well as from the edges of the sheet. This can best be done by the use of a stiff wire brush.

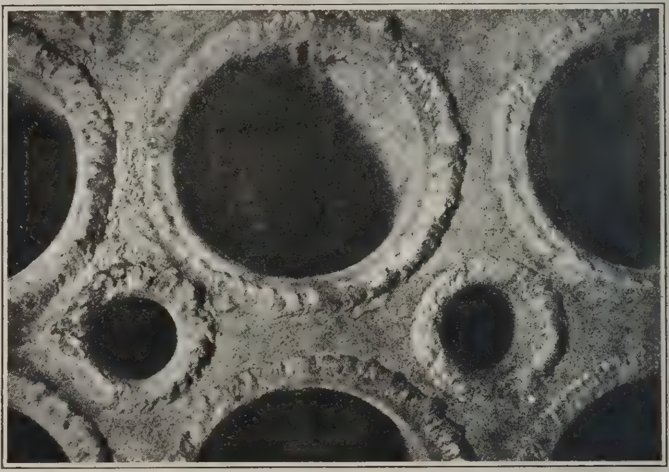


Fig. 5—Appearance of Welded-in Boiler Flues, a Job Always Done with the Metal Electrode

Where long seams are to be welded, as for example, in welding in a half-size sheet, practice again differs as to the best method of taking care of expansion. Some operators prefer to allow for expansion by widening the gap between the sheet, this being done by setting the new sheet away at a slight angle; the allowance usually made by these operators is about 1/8 in. to 1/4 in. per foot of length. Then when weld is begun at one end and work is carried on the two edges will gradually draw together, due to the contraction in the weld at cooling. Other operators prefer to place the two edges in final relation to each other, holding them at the proper distance apart by means of "tacks" at intervals of 12-in. to 18-in. The weld is then begun at either end and as it approaches a "tack" the tack itself is cut out by use of a chisel and solid metal welded in, the tack simply serving the purpose of holding the sheets in proper relation until the weld is made. When tacking is used, it has often been found advisable to weld a short space, say six or eight inches,

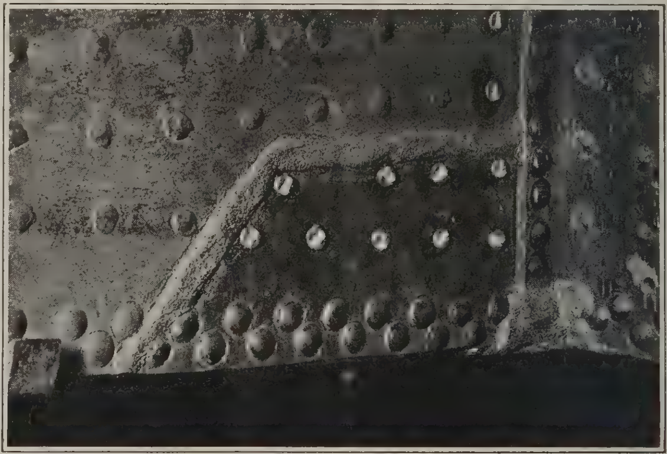


Fig. 6—A Patch Welded Into the Firebox

from one end of the seam then go to the other end of the seam and weld a like distance, thus keeping heating and expansion at a minimum.

In any event, troubles from expansion will be found at a minimum where the metal electrode arc is used as while the heat at the weld is very intense it is also very concentrated so that the total heat tending to expand the metal surrounding the weld is a minimum.

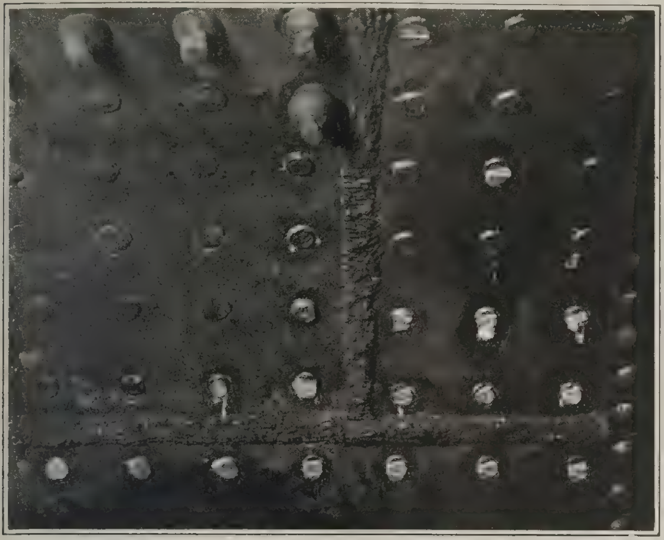


Fig. 7—A Patch Welded Into the Crown Sheet

Polarity of the Object

The object is commonly made the positive terminal, as in the Benardos method, although it is possible to reverse this relation with quite satisfactory results. Reversal of the connections causes the metallic pencil to become the point of greatest heat so that it melts away quite rapidly and may deposit upon the object when the latter is too cool. Reversal of connections, however, may be convenient in some cases, as for instance, field work in an electric traction system where the power is taken from the trolley. Under such conditions, if the object were made positive, careful insulating arrangements are necessary. If worn frogs or crossings are to be built up, the object is of necessity the negative terminal.

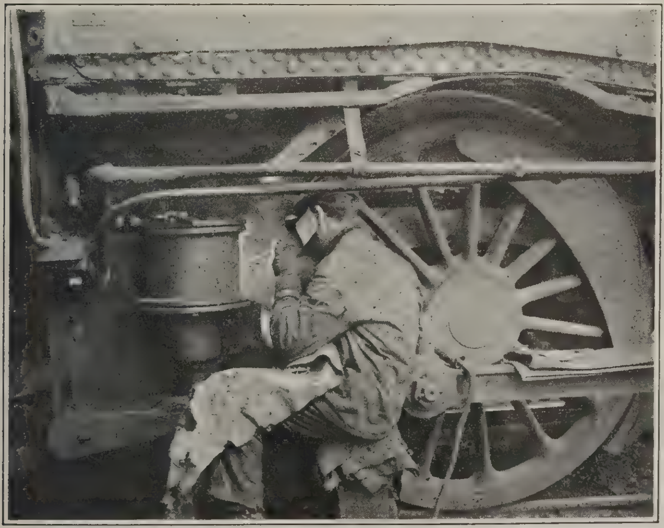


Fig. 8—Welding a Crack in an Air Brake Cylinder Support Casting

The process of welding with the metallic electrode is much like that using the carbon electrode, but since the arc is so short, a steady hand is required to maintain it. A little withdrawal of the pencil causes the arc to go out, while touching the object piece may cause the pencil to adhere. Supporting the arm helps to keep the hand steady. The pencil and the point of application should both be molten simultaneously and the movement of the pencil and length and intensity of the arc must be adjusted to obtain this condition, otherwise a good weld is not secured. Lengthening the arc slightly increases the heating at the piece. Inasmuch as metal is being constantly melted off and deposited, the pencil must be kept in gradual progression to prevent piling up of the metal in one spot. It requires considerable practice to obtain the right heat and right deposit simultaneously. A weld made by the metal electrode process does not usually require hammering as the grain is found to be closer and better than when the carbon electrode is used, but a little hammering does no harm, if done while weld is still at red heat.

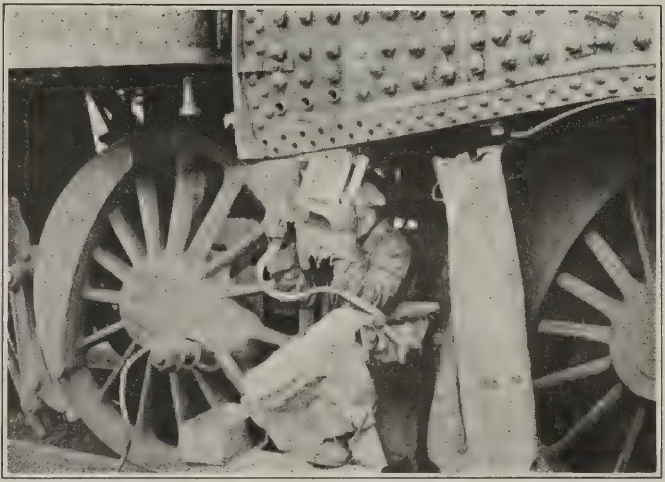


Fig. 9—Building Up a Mud Ring While in Place Preparatory to Applying a Patch to the Inside of the Firebox

Allowing for Expansion

The process of melting and filling in the metal does not comprise the entire art of welding as properly allowing for expansion, contraction and warping is a most important feature. In the case of castings particularly, difficulty is sometimes experienced due to cracking while the piece is cooling. The crack is most likely to occur at the weld, although pieces not infrequently crack at an adjacent point. Cracking may be caused by poor welding due to dirt or oxide or carbon from too short an arc, but it is more likely due to the shrinkage stresses incident to cooling. Any piece is larger while hot than when cold, consequently if a portion of a casting is hot and a portion cold it is easy for great strains to be set up. Cast iron will withstand little tensile stress, hence it cracks as the stresses incident to shrinkage are of great magnitude. To avoid shrinkage stresses is part of the art of welding, and considerable study may be given to this feature. Shrinkage troubles may be materially relieved if the casting is brought to a red heat before weling; then, after the work is completed, it should be allowed to cool slowly in the furnace or buried in lime or mica dust. Slow cooling is also necessary to secure soft metal in cast iron work. If an ordinary casting, when poured, is allowed to cool quickly, it becomes chilled iron, hard and brittle, likewise the cast metal flowing into a weld will become hard if cooled rapidly. It is easy for a weld to be chilled quickly as there is heat conducting metal all about it which will rapidly absorb its heat; hence the desirability of annealing.

Strength of Welds

The strength of electric arc welds is usually about 70 per cent of the strength of the metal, assuming that cast steel is being welded. With machine steel the weld should be of 80 per cent efficiency. The metal which goes into the weld is really in cast form, although its grain may be improved by hammering. In many cases the strength of the weld is not of prime importance, as when filling holes, building up worn surfaces and similar work, but if the strength of the weld is important it is often possible to make up in quantity of metal what is lacking in quality by building on extra metal at the weld and over the adjacent section. Metal may be added or built on by the arc process with impunity and to a nicety.

Arc welding is most effective on wrought iron and steel. Welds on cast iron are not always reliable and malleable iron cannot be dependably welded by any process.

Benardos v. Slavianoff Process

Each method of arc welding finds its advocates. The Benardos process was originally most used, but the Slavianoff process is probably more popular at present. The Benardos process affords greater heat volume and is best suited for heavy work where speed of application is desirable, and where the quality and finish of the weld are of secondary importance. The Slavianoff process usually gives a more reliable weld, gives finer texture to the metal, leaves it less porous, can be more neatly executed and finished, requires less power and may be easier controlled. The Benardos process is well suited for filling holes in large castings and similar work, but the Slavianoff process is best for building up metal on surfaces since the addition of metal is largely automatic and the confinement of the heat avoids flowing and run off tendencies; in other words the added metal stays where it is put. With suitable control provisions, it is possible to combine methods, heating the working zone by the use of the carbon arc and building up the new metal with the metal electrode, the procedure depending upon the character of the work and the ability to reach the molten condition simultaneously upon object and electrode.

Field for Arc Welding

The field for arc welding is extensive and is rapidly widening as the usefulness of the process becomes realized. It is particularly well suited for repair work, as it is flexible and adaptable. In the railroad shop arc welding is extensively used for welding breaks in locomotive and car frames, the work being done with a minimum of dismantling. Worn parts are frequently built up by the addition of new metal; the illustration (Fig. 4) shows a welder building up a worn mud ring using the metal electrode process. Arc welding has been successfully used for the building up of flat spots on steel driving and car wheels, which avoids the life reduction incident to turning down the entire wheel. Welding the ends of flues is being recognized as superior to beading or expanding. The appearance of a welding job on flues is shown in Fig. 5. This work is done with the metal electrode. In addition to these specific applications many individual jobs of all sorts are subject to advantageous handling by this method.

The Arc vs. Oxy-Acetylene Flame

In flexibility or character of workmanship the arc process is not superior to the oxy-acetylene flame; in fact the gas process is more flexible and is considered by some workers to be better upon cast iron. For work on brass, bronze or aluminum the oxy-acetylene flame has no competition. The acetylene flame is also somewhat easier to handle as glasses alone are required, no hood or screen being necessary. The main point of superiority of the arc method is its economy, as the electric arc produces the necessary heat at a much lower cost than does the oxy-acetylene flame. In its field the arc also produces results as good, if not better than can be obtained with gas, e. g. flue welding. To avoid excessive cost, preheating is almost always necessary in gas welding, but may often be dispensed with in arc welding. The cost of electric power for a welding job will only be from 15 to 25 per cent of the cost of oxygen and acetylene for the same job.

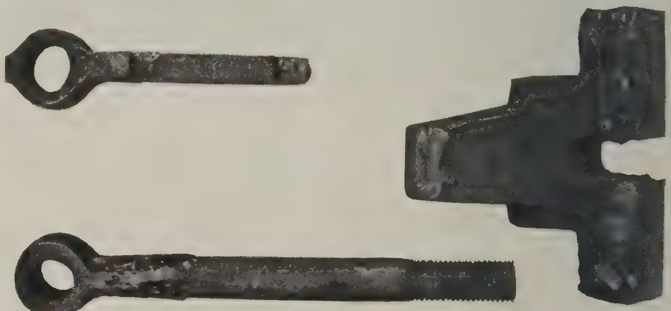


Fig. 10—Car Parts Which Have Had Their Worn Spots Built Up by the Metal Electrode Process

[We are indebted to W. A. Deems, master mechanic of the Staten Island Lines of the Baltimore & Ohio at Clifton, Staten Island, N. Y., for the photographs shown in Figs. 6, 7, 8 and 9 and also the photograph for the feature head.—Editor.]

California Heads List in Petroleum

The quantity of petroleum marketed in the United States during the first half year of 1916 is estimated by John D. Northrop of the United States Geological Survey at 140,000,000 bbls. His estimate is moderate and his apportionment of the output among the major fields is as follows: Appalachian, 11,400,000 barrels; Lima-Indiana, 1,800,000; Illinois, 7,900,000; Kansas and Oklahoma, 50,500,000; Northern and Central Texas, 4,200,000; Northwest Louisiana, 6,800,000; Gulf Coast, 11,400,000; Wyoming and Montana, 2,400,000; California, 43,500,000; miscellaneous (Colorado, Michigan, Missouri), 100,000; total, 140,000,000.—*Journal of Electricity, Power and Gas.*

Electrical Energy as a By-Product

By E. Wanamaker*

THERE has been little written on the subject of electrical energy as a by-product, and no doubt to many the subject is entirely new. However, there are three classes of power plants in which electricity is almost always a by-product to a greater or lesser degree, depending upon the actual existing conditions. The *first class* consists of power plants for furnishing electricity for power and lighting, pneumatic energy, steam for heating and any other form of energy that may be required, in industrial plants. The *second class* consists of power plants for furnishing all forms of power necessary for large office and mercantile buildings. The *third class* consists of power plants for furnishing all forms of power or energy required for railroad shops or railroad terminals.

We will consider the *third class* only. It is not the intention to go into detail regarding power plants for large passenger stations, as they partake more of the nature of plants furnishing energy for large office or mercantile buildings; it being understood that the same general rules will apply to all of the plants included in the three classes above mentioned. It is the intention, however, to go into detail regarding power plants for furnishing energy to railroad shops and terminals.

Generally speaking, the power plants for such service are of the variety known as mixed, by which is meant that energy is furnished in several different forms. (1) Live steam at high pressure for supplying round houses with steam for blowing engines (and until some successful form of power driven induced draft system is devised, it will be necessary to supply from twenty-five to fifty h. p. hrs. in high pressure steam for every engine that is fired up), for testing boilers, for operating steam hammers, etc. (2) Live steam at high pressure required for the development of pneumatic energy. (3) Live steam at high pressure required for handling and supplying all the water required, and for hydraulic energy. (4) Live steam at high pressure required for the development of electric current to be used as power for driving machinery, lighting, electrolytic plants, electric furnaces, electric welding, etc. (5) Live steam at high pressure for furnishing heat to all of the various buildings, unless the exhaust steam from the engines, pumps, compressors and turbines is to be used to supply the heat after it has furnished the power; vacuum pumps being employed to secure successful operation. It is by the use of this exhaust steam as a heating medium that we secure electrical energy as a by-product. Practically all plants operating where there are three or more months of winter weather can thus manufacture their electricity at a low cost.

In order to avoid confusion, it will be well to begin with the heating value of exhaust steam from the prime movers as compared to the heating value of live steam from the boilers. By taking the exhaust steam from a prime mover and condensing it in a tank containing water of known weight and temperature, it can easily be ascertained how much heat is available in any desired unit of exhaust steam, say, for example, per 100 lb. In a like manner, live steam can be measured and tested for its heating value.

Actual test shows that the average prime mover removes only about four per cent of the total heat in the steam. With this in mind and assuming that the condensed water in the radiator return pipes contains eight per cent of the original total heat that was in the steam at boiler pressure, it is evident that 88 per cent of the total heat in the steam is still available for heating purposes after it has gone through the prime mover. A theoretical check on these figures may be of interest. Assume that an engine or turbine driving a generator takes steam from the boiler at 125 lb. gage pressure and releases it into the heating system at 5 lb. back pressure. Reference to the steam tables shows that the total heat in the steam at 125.3 lb. is 1192.2 b. t. u., and at 5.3 lb., 1156.2 b. t. u. The heat converted into work in the prime mover is, therefore, 1192.2—1156.2 or 36 b. t. u., which is only 3.02 per cent of the total heat that was in the steam as it came from the boiler. Now assume that the exhaust steam is used in a vacuum heating system where a vacuum of 11.60 in. of mercury is obtained. When going through the radiators of such a heating system the steam is condensed and loses all of its heat except that in the condensed return water, which, by reference to the steam table, is only 156.2 b. t. u. at a 11.60 in. vacuum or 13.1 per cent of the total heat in the steam. The only heat that is not available for heating then is the 3.02 per cent converted into work and the 13.1 per cent remaining in the return water or a total of 16.12 per cent. This means that 83.88 per cent of the total heat in the steam at boiler pressure is available for heating purposes after it has passed through the prime mover. Our theoretical conclusion checks closely with the figure (88 per cent) given in the first part of the paragraph. This example does not consider the loss in pressure and heat between boiler and throttle nor other small refinements but is sufficiently accurate to show the small proportion of the heat in the steam that is used in the prime mover and the large proportion that is available for heating. The reason for the large amount of heat in the low pressure steam for heating purposes is that a large portion of the heat is in the form of latent heat, which is only liberated during the process of condensation. It is this fact that establishes the value of the low pressure exhaust heating system.

It is possible to say, therefore, that when all of the heat in the exhaust steam from prime movers, including water of condensation, is used for heating purposes the fuel cost of steam engine power may be practically nothing. This means that the fuel cost for generating electric energy with steam engines is negligible if the exhaust steam is used for heating so that electrical energy obtained in this way can justly be considered a by-product.

It is well to bear in mind that a large number of mixed power plants, such as come third in our classification, have not been carefully or efficiently managed and operated. It is difficult, however, to see why such plants should not be given the same care and attention as any other part of a railroad system, for certainly there is no place where it is easier to procure efficient operation, provided competent men are employed. We will proceed on the assumption that the plants about which we are writing have been properly designed and are being economically and efficiently operated, as it would require much time and space to cover these two points alone. It is also necessary to see that the proper accounting is made, and it is here that many grievous mistakes are made. The writer knows of many plants in which absolutely no charge was ever made for the steam heat supplied, the total cost of this heat being added to the actual cost of generating electric current. Sometimes still other costs are unjustly added to the cost of generating the electric energy. The accounting should be arranged so that only the fixed charges on that part of the equipment which is used solely for the generation of electric current should be included in the cost.

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Before it is possible to ascertain the cost of producing electric current in a mixed plant, it is imperative that the amount of steam supplied to the heating system be found and a deduction made proportionately. For instance, if we know that it costs approximately $0.005 per b. h. p. h. for steam, equal to 34½ lb. of water or steam per hour, and that it requires approximately .015 lb. of steam per cubic foot of space heated per hour, when raising the temperature from approximately 24 deg. to 70 deg., we deduce that it would take 1.5 lb. of steam for each 100 cubic feet of space heated per hour. To heat this space for 24 hours would require approximately 36 lb. of steam which would cost $0.005. It therefore costs $0.005 a day for each 100 cubic feet of space heated or $.15 for 30 days. Thus to heat a room 10 ft. x 10 ft. x 10 ft. would cost $1.50 for 30 days. Using the cost of $.15 per month for heating a space of 100 cubic feet as a unit, it can easily be ascertained what it costs on an average for heating any building, the cubical contents of which are known.

Different factors for forming the unit cost have to be used, basing same on the general type of the building to be heated, the average temperature and the cost of producing a b. h. p. After the deduction of steam heating cost has been made, it will then be necessary to ascertain what proportion of the steam is actually required for the generation of electric current. For detailed information on proper distribution of costs, see the June, 1916, issue of the *Railway Electrical Engineer,* which contains a paper on "Method of Cost Keeping for Railroad Shop Power Including Various Forms of Energy Required."

Going further, take, for example, a plant producing a total of 100,000 kilowatt hours per year, 50,000 of which are made during the winter months when the electricity is practically a by-product due to the use of the steam for heating. The cost during the six winter months would probably average $0.001 per kilowatt hour, which makes a total cost of $50.00 for the 50,000 kilowatt hours. For the other six months the unit cost per kilowatt hour would probably be $0.01, so that the cost of the other 50,000 kilowatt hours would be $500.00, thus making a total cost of $550.00 for the 100,000 kilowatt hours, which is an average cost of $0.0055 per kilowatt hour for the year for current at the busbar on the switchboard in the power plant.

In most railroad shop power plants it is necessary at night to turn live steam into the heating system which makes it possible to carry a large night lighting load with practically no expense for current. This also makes good yard lighting and interior building lighting possible which reduces the insurance rate and increases the efficiency of those who work at night. This is especially true if the switching yards are properly lighted, a fact that has been almost entirely lost sight of. The writer has found the above to exist in every plant with which he has been connected.

In the winter when the heating load is heaviest, the demand for electric current is likewise the heaviest, due to the increased lighting load. At this time the demand for steam heat is larger than the demand for electricity, which means that all of the exhaust steam is used for heating.

There is, in the great majority of all railroad shop power plants, what is known as a stand-by charge, based on the fact that the entire steam plant has to be held in readiness at all times with a reserve to meet any demands which may be made upon it. Therefore, should the electric load be light, as it generally is when the stand-by charge is the heaviest, the fuel cost is practically absorbed in the stand-by charge. A practical example of this was shown on a certain railroad not long ago where a small engine and generator supplied all the current used at that point. Due to the failure of a motor at a larger point, it was found necessary to remove this generator to replace the motor. In the meantime current was purchased from the local power company. As actual results showed the coal consumption was not rereduced, so that the cost of the purchased power was simply an additional expense. Needless to say, another generator was installed as soon as possible.

In practically all of the railroad shop power plants, it is not necessary to hire additional help where electric generating equipment is used; hence, there is practically no labor charge.

It has frequently been said that the smaller plants, such as we are considering, are not reliable as regards continuity of service. The writer has been making a close check of such plants and has found that they are almost 100 per cent reliable and that the service is practically continuous. On the other hand, in five different shops where the current has been purchased from large power companies, there has been an average of five delays per year, each of over two hours duration. These delays were due in almost every instance to transmission line troubles, the service not being considered of enough importance to the power company to warrant a duplicate line or else the power company was selling the current so cheap, in order to get the business, that it did not feel justified in spending the money necessary to insure the service.

It is therefore evident that the mixed plants for railroad shops and terminals, properly designed and installed and efficiently operated, are capable of making current cheaper than it can be purchased, as long as electricity can be made during the winter months as a by-product; but, whenever the demand for electric energy is heavier than the demand for steam heat, it will be necessary to make a careful investigation to see whether or not this would hold true.

Mechanical Design of Electric Locomotives*

C. H. Quereau, Superintendent Electric Equipment, New York Central, and C. E. Eveleth, Engineer, Car Equipment, General Electric Company, Discuss A. F. Batchelder's Recent Paper

C. H. Quereau.—In the main, I agree with the conclusions which Mr. Batchelder has reached. However, it seems to me very unfortunate that this paper, as well as others recently presented, is simply a general statement of the conclusions of the writer rather than a statement of accomplished results. I am reminded of the discussions indulged in about ten years ago, before any considerable electrification of steam railroads had been accomplished. These discussions were based almost entirely on personal views and theories, without any demonstrations. At the time of which I speak this was necessarily so, but there should now be available accurate figures based on actual operation. This criticism, in general, is true of all electrification papers, probably due largely to what appear to me to be mistaken ideas on the part of those who have the facts or those who have the authority to make them public. That Mr. Batchelder appreciates this is shown by the last paragraph of his paper.

In Mr. Batchelder's paper I would suggest that Item 4 read: "Convenience of Arrangement as Affecting Safety, Efficiency of Operation and *Maintenance.*" It is quite probable that convenience of maintenance was in the author's mind, but it seems to me of sufficient importance to be mentioned specifically.

The discussion under the heading "Safety of Operation," I must confess that I cannot quite follow, probably because I do not clearly understand what was written, or have not the information on which the author bases his opinion. I have believed that the angular motion of a four-wheeled truck was about its inner rear wheel, the fact being that when a truck is on a curve the outer forward wheel flange and the inner rear wheel flange are against the rail, the other two flanges not touching the rail.

The operating advantages gained by having electric locomotives designed to operate in either direction are of such great importance that means must be found to provide satisfactory designs to meet this condition. The chief difficulty with present double end locomotives is the oscillation of the trailing truck, which Mr. Batchelder proposes to prevent by the introduction of resistance against swivelling. This scheme is practical and has been so demonstrated, but it results in increased flange wear, at least when the center of gravity is low.

I am particularly interested that the item of "Reliability in Service" has been given an important place in the list of requirements for electric locomotives. This is a feature which quite commonly is omitted in a discussion of this kind. On railroads which run through a sparsely settled country with comparatively few trains per day, a train delay of half an hour may be of comparatively little importance, but in eastern territories, especially around the large cities, a delay of a few minutes will upset the smooth operation of the railroad for hours and the effect of it reach back on the line for 150 miles. It is my opinion that the prevention of such delays justifies a considerable increase in first cost, and also that such maintenance methods should be employed that will prevent, as far as possible, delays to traffic. It is decidedly poor policy to reduce maintenance costs if by so doing the result is increased traffic delays.

In my judgment Mr. Batchelder very wisely considers the "Cost of Maintenance of Permanent Way" of more importance than "Cost of Maintenance of Locomotives." I believe, however, that if the cost of maintenance of way is no greater under electric than steam operation, it would be satisfactory and would not be used as an argument against electrification.

As to the cost of maintenance of electric locomotives: The difference in the cost of maintenance at the rate of 3.5 cents a mile and 7 cents a mile is approximately $1,000 per engine per year. This saving, capitalized, represents a considerable sum, and would warrant an appreciable increase in first cost. The sum mentioned is 10% of $10,000, or 5% of $20,000.

With half a dozen different designs of electric locomotives, no one has had the advantage of experience with more than one of these types. Therefore, one's conclusions as to other types are based on opinions and theoretical considerations rather than actual results as shown by service records. So far as I know there have been published very limited data as to service results. If it were possible for this society, as a neutral, to obtain statistics covering the main points as to results in service, extending over several years, and make them public, they would be of decided value.

The New York Central electric locomotives are all equipped with bi-polar, gearless motors mounted directly on the driving axle. The operating results have been completely satisfactory to the officers of every operating department affected. This statement, you will note, does not include the net financial returns from the investment, which must take into account the item of fixed charges.

With the usual maintenance these locomotives ride satisfactorily, do not have any undue effect on the track structure, and are perceptibly more comfortable than steam locomotives. In order to secure these results it is necessary to keep the total lateral motion, both in the boxes and center-pins, within limits which approximate three-quarters of the allowable lateral motion on steam locomotives.

Table I contains statistics which will permit a personal conclusion as to the reliability of these locomotives

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*Discussion of a paper on this subject presented by A. F. Batchelder before the American Society of Mechanical Engineers, December 8, 1916, and published in abstract in the November *Railway Electrical Engineer.*

in service, and which will probably be more satisfactory than any general statement or expression of opinion, no matter how authoritative:

TABLE I.

TRAIN DETENTIONS DUE TO DEFECTS IN ELECTRIC LOCOMOTIVES.

	Miles Per Detention—All Locomotives.		
Year	*Mechanical*	*Electrical*	*Grand Total*
1912	48,271	103,967	32,965
1913	27,873	86,716	21,093
1914	35,625	57,395	21,981
1915	53,720	107,440	35,813
Type "S" Locomotives (Rigid Frame)			
1915	59,583	187,260	45,201

Note: All detentions of two minutes or more included. In 1913 and 1914 there was a total of 16 Class "I" locomotives placed in service. In 1912 there were 47 locomotives in service. Since the middle of 1914 there have been 63. Detentions due to man failures, or delays to following trains, not included.

In this connection I wish to enter a strong plea for the use of "Miles per Detention," instead of "Miles per Minute Detention," as the unit in the preparation of statistics by which to judge the reliability of equipment in service and the efficiency of the organization responsible for maintaining it. Including the time element leads only to confusion and is, therefore, worse than useless.

TABLE II.

INSPECTION AND REPAIRS OF ELECTRIC LOCOMOTIVES.

	Cost, Cents Per Mile.		
Year	*Labor*	*Material*	*Total*
1912	1.888	1.460	3.348
1913	1.982	1.454	3.436
1914	2.155	2.134	4.289
1915	1.901	1.379	3.280

Note: The above statistics were compiled in accordance with the requirements of the Interstate Commerce Commission. In the year 1914 it was necessary to replace all driving wheel tires because of unsuitable material, regardless of the extent to which they had been worn. The costs of maintenance have been essentially as above since 1907, omitting 1914.

In studying Table II, the following facts should be borne in mind. These figures include the cost of inspection and maintenance of all the electric locomotives, both road and switch. In 1912 and 1913 approximately half the total engine mileage and in 1914 and 1915 approximately one-third was that of engines used in switching service. Our experience has shown the cost of maintenance of engines in switching service to be about twice that of those used exclusively in road service. It follows that the cost of maintaining the road locomotives has been about 2.5 cents per mile and that of the switch engines about 4.8 cents per mile. In this connection it is only fair to call attention to the fact that these engines were not designed for switching service. Bearing this in mind, they have given remarkable results.

For the first ten months of 1916 the average cost of maintenance of all the electric locomotives has been 2.73 cents per mile. This gives a cost of approximately 4 cents per mile for the locomotives in switching service and approximately 2 cents per mile for those in road service. I expect these costs will not be exceeded for the entire year 1916, but very much doubt that we will be able permanently to keep the maintenance costs at this level.

C. E. EVELETH: When an occasion arises to examine critically different designs of electric locomotives there is almost always a tendency, due to the individual's interest in specific features, to concentrate on particular elements and rather superficially consider the locomotive as a whole, but in Mr. Batchelder's paper we are fortunate in having a clearly brought out presentation of all the essential elements. A number of the elements are intimately related to common features of design, particularly the subject of "Reliability in Service," "Service Time Factor" and "Cost of Maintenance" of locomotives which are all affected directly by the simplicity of parts.

Disregarding other features, the bipolar type of engine with its freedom from all gears, pinions, gear case, and motor armature and motor axle bearings has, as regards these three related subjects, a decided initial advantage over all other designs. It also has an unquestioned superiority in mechanical efficiency as shown by the table:

RELATIVE MECHANICAL EFFICIENCIES

Motor Design or Connection to Axle.	Mechanical Efficiency.
Bipolar gearless	100%
Quill drive	99
Geared drive (twin gears)	95
Geared to jack shaft and side rods	90
Direct connected jack shaft and side rods	87

The difference in power consumption due simply to the difference in the mechanical efficiency, may, when capitalized, amount to from one-third to one-half the original cost of the engines; in other words, to obtain the same overall economic result a material increase in investment in an engine of higher mechanical efficiency is justified, if such investment is necessary to obtain this type of drive.

In conclusion, it appears that considered from the mechanical design standpoint, Mr. Batchelder's claim for superiority of the bipolar gearless design for high speed service is founded on the incontrovertible facts that this type of engine is: Safe in operation; superior as to reliability and availability for service requiring no overhaul periods and requiring minimum inspection time; it has the lowest cost of maintenance on account of the elimination of gears, gear case, jack shaft, pin and motor bearings, and its maximum mechanical efficiency insures minimum power consumption.

With Mr. Batchelder's suggestion of the use of a truck center pin located in a well elevated position, all of the advantages of high center of gravity, so far as effect on rail displacement is concerned, can be obtained. On the other hand, with ordinary leading truck designs, it appears that the high center of gravity designs will give a low center of gravity effect by the action of the rear truck on the track unless the high center pin arrangement suggested by Mr. Batchelder is adopted on the trucks. These remarks, of course, refer to a symmetrically designed locomotive intended to run in both directions.

These features do not seem to have had general recognition, as they should place the bipolar gearless locomotive distinctly in a class by itself, and superior on account of these features to every other design. It is, therefore, to be expected that where a system of electrification will lend itself to the use of this type of engine, its application will become very general.

Killing Germs Electrically

A recently passed federal law requires a system of drinking water purification to be used on public carriers. An equipment using ultraviolet rays from a mercury vacuum light has proved successful for this work and is being installed on many of the large lake passenger boats. A mercury tube is immersed in a tank or receiver in the water system so that all the water used is at one time or another exposed to the ultraviolet rays from the tube. Inasmuch as the mercury tubes require 220 volts, direct current, and the lake boats have but 115 volts available, motor generator sets must be provided to operate on 115 volts and provide 220 volts for the lamps. The operation is automatic; if the tubes burn out or the voltage fails, the electrically controlled intake valve of the tank is closed. The Western Electric Company recently furnished six motor generator sets for use on passenger boats.

Fire Hazards of Electric Power and Light Wiring*

This report takes up in brief the principal hazards which exist around electric installations used for power purposes. The report also deals with what are termed the hazards of signaling systems. These, however, are dependent only upon the possibility of the signaling systems becoming crossed with electric wires or a lightning discharge.

The hazards of electric power, outside wiring installations and signaling systems, are more or less related to those present with Electric Lighting Installations and this report is given as a supplement to Bulletin No. 7, "Hazards of Electric Lighting Installations."

Committee—T. S. Potts, chairman; H. J. Davies, S. H. Lawrence, W. T. Witter.

Cause of Hazard.	Probable Effect.
Auto Starter.	
Permitting auto starter without approved dust-proof case in vicinity of inflammable dust.	Overheating would ignite material.
Using a combustible insulated wire connection between resistance elements and contact devices.	Overheated resistance may fire the combustible insulation.
Generators.	
Located in wet places.	Leaking currents likely to cause electrolytic corrosion of nearby gas pipes or find a path where they might cause damage.
Installed where hazardous processes are carried on. Near inflammable gases or flyings.	Sparking or burning out of generator liable to cause fire.
Not permanently grounding generator frame.	In case of machine wiring making contact with frame current is liable to arc to nearest ground and set fire to any combustible. Also dangerous to life.
Not equipping constant potential generators, excepting A. C. machines and their exciters, with protection devices.	An accidental short-circuit across the bus-bars or exposed metal parts of the main switch on the switchboard may burn out armature as well as do considerable damage where the short circuit occurs.
Placing conductors in concealed and inaccessible places and using improper insulation.	Since the wires are unprotected between generator and switchboard a defect is not readily discovered until serious damage has resulted.
Lightning Arresters.	
Omitting the installation of arresters on outdoor lines.	Lightning discharges entering building and doing damage.
Placed near combustible materials.	Material liable to be ignited if arresters discharge sparks.
Allowing kinks or sharp bends in wires between the arresters and outdoor lines.	Lightning discharge will have a tendency to jump to a more direct path to ground.
Running ground wires inside of iron pipe or attaching to gas pipes in building.	Iron pipe will tend to choke the lightning discharge. Also gas service may at some time be discontinued or meter removed for some other reason, thereby cutting off the ground connection.
Motors.	
Not permanently grounding base frames.	In case of machine wiring making contact with frame, current is liable to arc to nearest ground and set fire to any combustible. Also dangerous to life.
Neglecting to protect with cut-out and switch.	Possible burning out of motor due to an overload.
Installing in vicinity of inflammable dust flying without proper enclosures or under any circumstances in surroundings of inflammable gases.	Ignition of inflammable material due to sparking and burn-out. Certain types are only subject to burn-outs.
Hot bearings melting babbitt.	Short circuit when armature drops on pole pieces.
Rheostats.	
Installed near inflammables or in vicinity of dust or flyings.	Radiated heat is liable to ignite the material.
Using a combustible insulated wire connection between resistance elements and contact devices.	Overheated resistance may fire the combustible insulation.
Signaling Systems.	
Running wires directly into a building without drip loops.	Water is liable to follow wires and corrode inside connections, making them too weak to withstand a stray voltage.
Not using proper insulating bushings where wires pass through walls.	In case of foreign currents on line wire insulation is liable to break down and fire may ensue.
Not installing all systems to eliminate as far as possible crosses with electric light or power wires.	Foreign current will probably burn out instrument or arc to building and cause fire.
Not grounding protectors or poor ground connections.	No safe path for lightning or sneak current discharge to ground.
Running wires inside iron pipe or attaching to gas pipes in building or steam or hot water pipes.	Iron pipe will tend to choke the discharge. Gas service may at some time be discontinued or meter removed for some other reason, thereby cutting off ground connection.
Installing on buildings without proper insulators and using wires without proper insulation.	Foreign currents on line are liable to arc to building material.
Adjacent to electric light or power wires.	Crosses would probably result.
Omitting fuses and lightning arresters near entrance of wires to building.	Lightning or heavy crossed current discharges can reach inside wiring and apparatus and cause damage.
Switchboards.	
Placing switchboard near inflammable material.	A flash due to an accidental short-circuit across live parts is most likely to cause a fire.
Using combustible boards.	Easily ignited by small arcs.
Omitting the protection of all instruments with fuses.	Trouble is liable to arise from the delicate mechanism of the instrument and a heavy current due to a cross would not be disrupted.
Batteries.	
Not insulating the entire battery system for the voltage developed.	Leaking currents or jumping arcs would likely ignite any inflammables nearby.
Location in poorly ventilated rooms.	Making a condition where explosive gases can accumulate.
Transformers.	
Location in places where burning out or boiling over of oil could do damage.	Smoke liable to spread over a large area and prevent economical extinguishment of fire. Burning flowing oil communicating to other parts of the building.
Not permanently grounding transformer cases in central or sub-stations.	If wire insulation breaks down on case current is liable to arc to nearest ground and set fire to any combustibles. Also dangerous to life.
Not grounding the secondary system.	A cross between primary and secondary coils would subject the entire secondary system to the high primary voltage.
Outside Wiring.	
Using other than weather-proof or rubber insulated wires.	Rapid deterioration of insulation, leaving bare wire which affords no protection against crosses.
Wires too close together, too close to awnings, signs, shutters, guy wires, metal roofs, etc.	Rubbing off of insulation, allowing crosses and grounds.
Using knobs, cleats or other than petticoat insulators.	Leaking currents and possible arcing.
Not grounding cable sheaths at intervals.	Breakdown in wire insulation practically makes cable a bare, live wire.
Placing high tension lines on poles with other wires, too near buildings without due consideration of the hazard.	Danger of getting high voltage on low potential wires due to contact. Retards work of firemen.

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*Abstract of electrical committee report at the third annual meeting of the Railway Fire Protection Association, held at Hotel Astor, New York, Oct. 3, 4 and 5, 1916.

Care of Electrically Operated Turntables

By J. H. Wickman

If a turntable is properly installed, leveled and balanced, the entire weight is carried on the rollers which are a part of the center casting. These rollers should be supplied with at least two quarts of high viscosity oil every month keeping them a little more than half submerged in oil. Keeping these rollers properly oiled and in good repair will keep down the amount of power required for operating the table.

The track wheels need but little care after being installed if the boxes on either side are properly packed with oiled waste, which is replenished every two months. If the table is kept at the proper height with reference to the circular track, the track wheels will be about an inch off the track with the table carrying its maximum load, or somewhat more than an inch at no load. The circular track should be leveled at all points, as an uneven track interferes with good operation and increases the cost of maintenance.

Motor Equipment

The slip ring a. c. motor and the series direct current motor have been found the most suitable for operating turntables, the principal requisite being a high starting torque, which is absolutely necessary for starting a table with a heavy engine on it. The motor commonly used is the slip ring a. c. type. The controller operates by cutting out resistance in the rotor circuit to bring the motor up to speed. One type used is the Allen & Bradley controller which uses carbon pile resistance which is varied by pressure, the motor being accelerated by slowly moving the operating handle, compressing the carbon piles and decreasing the resistance. The controller is so arranged that the handle is moved to one side or the other according to the direction in which it is desired to move the table. Other types of controllers use grid resistors similar to street car control; either type is reliable, however considerable trouble has been experienced from broken grids and contact fingers used on the latter type.

Trouble is sometimes caused by an open circuit in the rotor. To test for this use two lamps in series across each pair of rings with the motor at a standstill; when power is thrown on the lamps should all burn, if not, it indicates an open circuit between rings. Another source of trouble may be an open circuit in the starting resistance. This may be tested for by connecting lamps in series with each slip ring lead. Before making any tests on the rotor circuit of a slip ring motor, however, it is always advisable to make sure that the supply circuit is all right and no primary fuses are blown. One fuse blown on a three-phase circuit will prevent starting the motor.

An 85-ft. turntable, which is long enough to accommodate a Mikado engine, can be operated satisfactorily by a 15 h. p. motor. Such an equipment should make one revolution of the table in 60 or 70 seconds, requiring about 250 watt hours per revolution.

Brakes

Every turntable that is electrically driven should have a brake which is easily operated and has sufficient power to stop the table quickly. The correct place for applying braking power has been the subject of many discussions; the early method of applying it to the main driving wheel has been found unsatisfactory on account of sand carried up by the wheel and wearing off the face of the brake shoe. The modern method is to apply the brake on a separate wheel on the counter-shaft between the motor and the main driving wheel; it is then sufficiently effective both to overcome motor momentum and to brake the track wheel gear sufficiently to slide the wheel if desired.

Emergency Operation

When the power is off or electrical apparatus out of order it is necessary to operate the turntable by hand. From tests it has been found that the number of men required to turn an engine may be reduced by one-half if a few minutes' time of a machinist is spent in disengaging the motor pinion from the counter shaft. This relieves the men from overcoming the momentum and friction of the motor and gears.

Some "Don'ts"

As the turntable motor is a badly abused piece of apparatus, it is appropriate to call attention to the following "Don'ts:"

Don't use the motor as a brake for the table by reversing it.

Don't leave the motor exposed to the weather.

Don't forget to oil it when the oil is low in the gages, with a good light gas engine oil or dynamo oil, not common engine or car oil.

Don't put in so much that the oil overflows on the windings, this is just as bad as not any.

Don't try to turn the table if the rails or the table floor are binding on the circular wall, because it overloads the motor and will burn out something or blow a fuse.

Don't think the turntable motor is like a shop motor, because it is subjected to starting strains fifty times where a shop motor is once.

Give the motor due attention, and with fair treatment it will do its work.

American Railway Association

At the fall session of American Railway Association which was held at the Biltmore Hotel, New York city, on November 15, the following roads were elected members of the Committee on Electrical Working: Baltimore & Ohio; Chicago, Milwaukee & St. Paul.

The committee on Electrical Working, George Gibbs (Long Island), chairman, presented a report recommending for adoption an amended diagram of third rail working conductor clearances; and a simplified diagram of these clearances for the use of car inspectors. In the standard now recommended the "designing line" is fixed 18¼ in. from the track gage line and 6½ in. above the top of rail.

As a result of a study of clearances for overhead working conductors, it is recommended that the committee on standard freight car equipment consider the question of limiting the height of the brake staff on box cars to 15 ft. 3 in. In connection with this subject the committee reprints the five diagrams for overhead clearances adopted by the association in 1914.

Electric Traction Calculations

I

By A. J. Manson*

IN the design and operation of a system of electrification for a steam railroad certain fundamental and definite problems are encountered by the railroad electrical engineer. Trains of various lengths and weights must operate over the road around curves and up and down grades at speeds determined by the time table. The hauling of these trains requires certain sizes and types of electric locomotives which must be designed and built according to definite specifications.

Prior to the application of electricity to transportation, the capacity of the locomotive was usually determined by the cut and try method. Many times a steam locomotive would be purchased and the number of cars it could haul would be determined by trial. With the application of electricity a more careful study is made of the operating conditions; the grades, curves and speeds are considered and, by calculations and graphic methods, it is possible accurately to specify the size of locomotive or car required to perform the service.

General Principles Relating to the Operation of Trains

The capacity and horse-power of the electrical equipment to perform a given service depends upon the following:

1. The profile of the line which shows the grades and curves over which the trains must operate.
2. The weight of train to be operated.
3. The number of stops and their location.
4. Schedule speed required.

It hardly requires mentioning that a line which has heavy grades, sharp curves, etc., will require electrical equipment of greater capacity than one of very few grades. It also is clear that the greater the train weight, the greater the capacity required for the same speeds.

The number of stops and location of these stops determine the capacity of the electrical equipment. The larger the number of stops for the same schedule speed, the greater the capacity required. More time is taken up with the greater number of stops and it is necessary to operate at higher speeds between the stops, hence requiring greater horse-power in order to operate at the same schedule speed.

The schedule speed is the distance in miles divided by the total time in hours. This must not be confused with the average running speed which is the distance in miles divided by the actual running time and does not include the time taken by the stops.

Tractive Effort

To start and to haul a train requires that the electric locomotive exert a certain draw-bar pull. This power must be applied at the rim of the driving wheels and the weight of the locomotive must be such that sufficient friction will exist between the driving wheels and the rail to make slipping impossible. The power given by the electric motors is transmitted through the mechanical connections to the rims of the driving wheels where it is called tractive effort.

Tractive effort, which is usually represented in terms of pounds, has a definite relation to the torque of the motor, and is determined by the mechanical connections between the motors and the drivers. The mechanical connections may be in the form of gearing, or side rods, or a combination of both. The torque of the motor is the pull at one foot radius so that the tractive effort (T.E.) can be easily determined from the following formula when the motor torque curve is available:

$$\text{T.E.} = \text{pounds torque X} \frac{24 \text{ inches}}{\text{wheel diam. in inches}} \text{X}$$

ratio of mechanical connections X efficiency of transmission. If gearing is used then the ratio of mechanical connections becomes

$$\frac{\text{number of gear teeth}}{\text{number of pinion teeth}}$$

and the efficiency is the gear efficiency. With side rods, as used on the Pennsylvania electric locomotives, the ratio becomes 1 as the motors revolve at the same number of revolutions as the drivers.

The tractive effort delivered at the rim of the locomotive drivers is consumed in overcoming certain factors, namely—train resistance, acceleration, grade resistance, and resistance due to curves. Train resistance is the tractive effort required to keep the car or locomotive moving over a level track at a constant speed. Acceleration is the rate of increase in speed of the train and a certain tractive effort, additional to that required to overcome train resistance, is required to start the car or train and bring it up to a uniform speed. When operating on a grade an additional tractive effort is necessary to lift the car through the vertical distance which the car is raised when operating over the grade. Additional resistance is encountered and requires additional tractive effort when the locomotive or car is operating on a curve. There is a tendency for the locomotive to travel in a straight line and the centrifugal force set up causes the wheel flanges to press against the outer rail, friction greater than the train resistance results which must be overcome by additional tractive effort.

Train Resistance

Train resistance depends on a great many variables and at best it is necessary to assume average conditions. There are many empirical formulæ for train resistance which agree closely with actual tests which have been made. The effect of train resistance assumptions on the final result depends a great deal on operating conditions. In the case of rapid transit or local passenger high schedule service, the stops are at such close intervals that the energy consumed during acceleration is a large percentage of the total consumption. Inaccuracies in train resistance, under above conditions, do not affect appreciably the results. However, in the case of long runs where the train is accelerated infrequently, it is essential to use values for train resistance which are correct as the energy required to overcome train resistance becomes an appreciable part of the total energy expended in propelling the train.

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*Westinghouse Electric & Manufacturing Co., New York, N. Y.

The train resistance is affected by the shape, weight and size of the car or locomotive and can be divided into three component parts, namely—wind resistance, rolling friction and journal friction. Wind resistance depends on some power of the speed not yet determined; rolling friction is inversely proportional to the speed; and journal friction is for all practical purposes considered constant. At the instance of starting, the train resistance is high depending on the design of the bearing, the wheel diameter and the condition of the track. A value as high as 15 to 17 lb. per ton is probably reached but drops rapidly to a much lower value at two to three miles per hour and then rises gradually as the speed increases.

In working out the speed time curve, as we will see later, a constant value of train resistance is assumed over the period of straight line acceleration. Tests of train resistance check fairly closely with the empirical formulæ and in the working out of problems the following curves will be found accurate and will give satisfactory results. These curves are conservative and do not give as low train resistance values as some of the other curves based on formulæ, or as low as the Berlin-Zossen tests made in 1903. These tests were made in Germany on a high speed electric car of approximately 103 tons, operating over a specially prepared track suitable for very high speeds. Usually the problem is to determine motor capacity so that conservative values of train resistance are in the right direction.

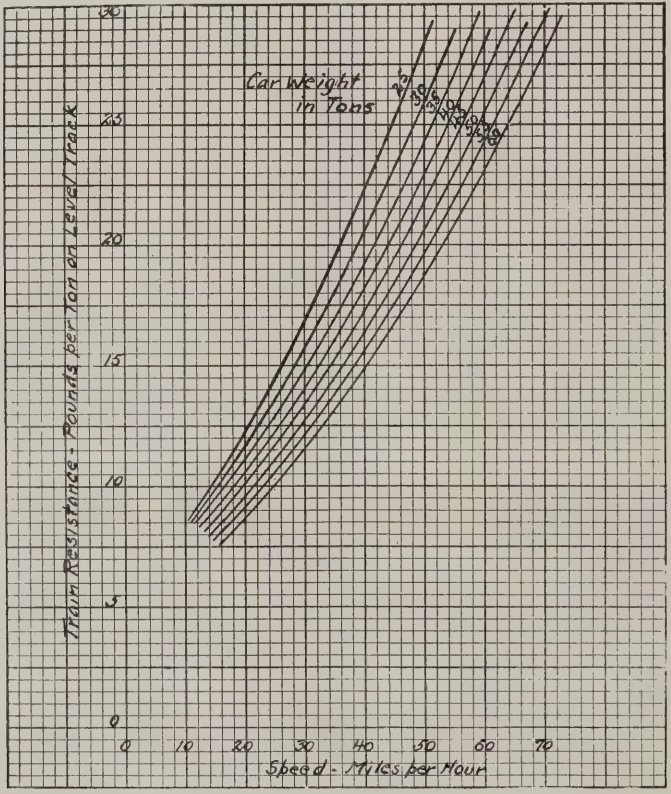


Fig. 1. Train Resistance Curves for Single Cars Varying in Weight from 25 to 60 Tons.

Curves of train resistance for single cars varying in weight from 25 to 60 tons are shown by Fig. 2, while Figs. 3 and 4 are train resistance curves for trains of various weights. These latter curves are obtained from Sprague's Formula

$$TR = 4T + \frac{VT}{6} + \frac{V^2}{3}$$

T R—train resistance
T—weight of train
V—speed

For general use and quick calculations, the following values can be used without referring to the train resistance curves. However, when any comparisons are to be made or speed time curves worked out then the curves should be used.

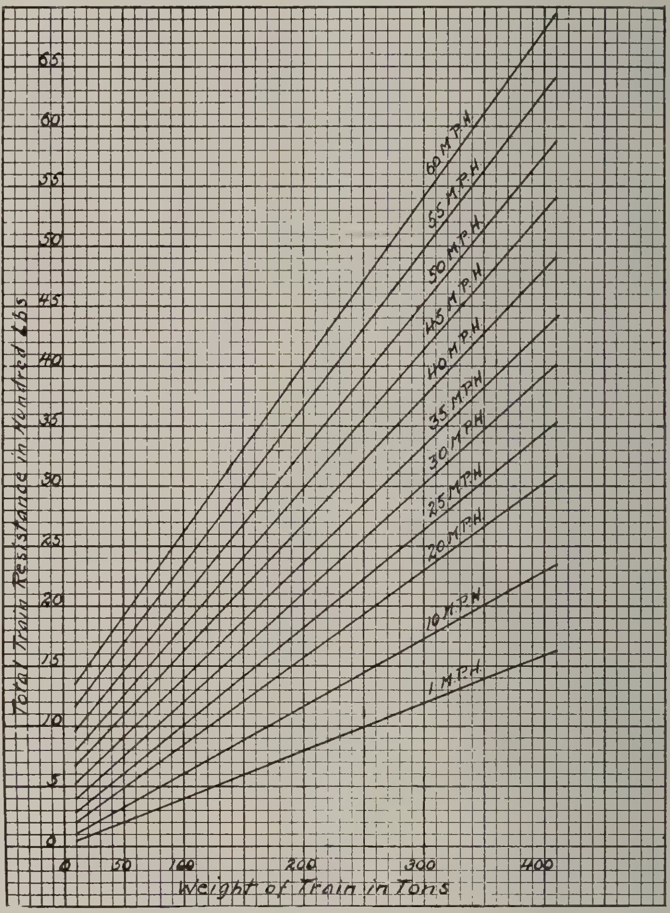


Fig. 2. Train Resistance Curves for Trains Weighing Up to 400 Tons at Various Speeds Up to 60 Miles Per Hour.

Electric locomotive resistance is usually taken at 15 lb. per ton and the trailing load for freight service at about 7 lb. per ton up to a speed of 30 miles per hour. With small light cars of approximately 30 tons weight a resistance of 20 lb. per ton up to 35 miles per hour can be used. In the case of heavier cars of 50 to 60 tons, 15 lb. up to a speed of 35 to 40 miles per hour and 22 lb. at speeds above 40 miles per hour and up to 60 miles per hour. When trailer cars are used in connection with the multiple-unit system then additional train resistance for these trailer cars can be taken at 12 lb. per ton for speed up to 50 miles per hour and 13 lb. per ton from 50 to 60 miles per hour

Acceleration

The acceleration of trains varies greatly. In rapid transit service, usually handled by multiple-unit operation, values from 1.5 to 2 miles per hour per second are used. Considering electric locomotives in freight service, the acceleration rate is, of course, a great deal slower and values of 0.1 to 0.2 miles per hour per second are used. In passenger service electric locomotives accelerate as high as one mile per hour per second.

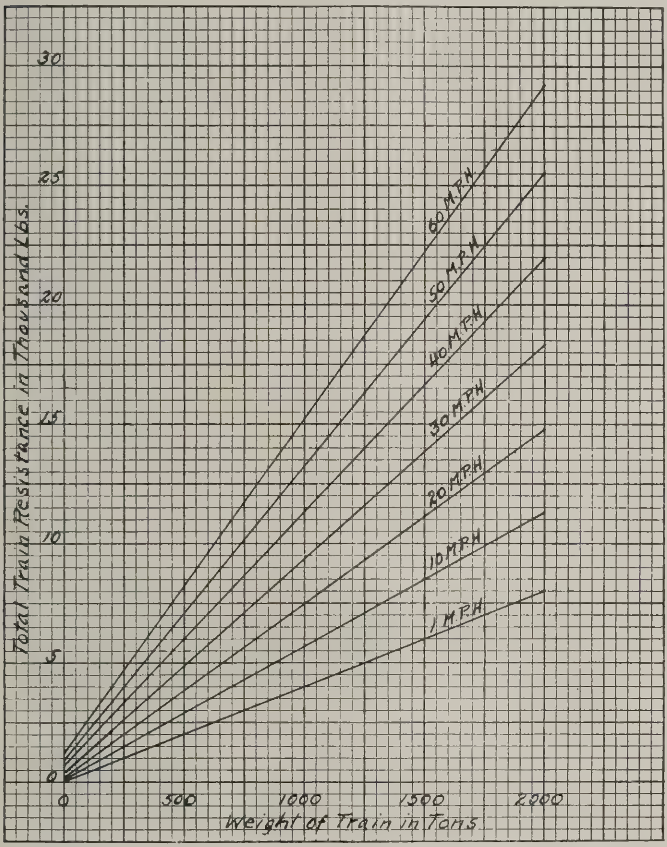


Fig. 3. Train Resistance Curves for Trains Up to 2,000 Tons for the Various Speeds Up to 60 Miles Per Hour

Acceleration is the rate of change of velocity. The force necessary to produce this acceleration is proportional to the product of the mass and the rate of the acceleration, i. e.—

$$F = \frac{W \times A}{32.2}$$

W—Weight of body in lbs.

A—Rate of acceleration in feet per second per second. The value is 1.47 for 1 mile per hour per second acceleration.

Using one ton or 2,000 lb. in the above formula and the rate of acceleration one mile per hour per second (m.p.h.p.s.) we obtain a value of 91.1 lb. per ton. This is the tractive effort per ton required to obtain rectilinear acceleration at the rate of one m.p.h.s., but does not take into consideration the additional force necessary to overcome rotation of wheels, armatures of motors, etc. The value to be used as pounds tractive effort per ton to produce the above rate of acceleration is taken as 100 lb.

For any other rate of acceleration the value to be used is proportional; for instance, with a rate of acceleration of ½ m.p.h.p.s., 40 lb. per ton would be the value, or for 1¼ m.p.h.p.s., 125 lb. per ton. In starting up a train, the acceleration is usually rapid requiring large tractive effort, but this acceleration gradually falls off until uniform speed is reached when the only tractive effort required is that necessary for train resistance.

Grade Resistance

The grade resistance is the tractive effort necessary to overcome the lifting of the car through the vertical distance. When running up a 1 per cent grade, the force required is 1/100 of the car or train weight. In terms of tons, it is 20 lb. which is the value used. For any other grade, the resistance is directly proportional—for instance, if the train was operating on a 2 per cent grade, 40 lb. per ton would be used or if operating on a 0.75 per cent grade, 15 lb. per ton would be used.

Curve Resistance

The value to use for curve resistance in terms of degree of curvature is at its best only approximate. There are many factors such as track, road-bed, and speed of train which enter into and affect curve resistance. A value of 0.8 lb. per ton per degree of curvature is generally used although this resistance value may be taken as low as 0.4 lb. where the construction of the road-bed is of a high order.

Speed Time Curve

The operation of a train can be represented graphically by what is known as a speed time curve. The operation generally consists of a series of runs, the number depending on the number of stops which the train makes between the two terminals. At each stop, the train starts from standstill, increases its speed or accelerates at first rapidly and then more slowly until a balanced speed is reached. Power is cut off and the train coasts until a point is reached where brakes are applied to bring the train to a standstill at the next stop. Each of these cycles of operation can be shown graphically by plotting speed against time as shown in Fig. 1. Acceleration is shown by the line *A-B;* the constant speed by *B-C*; coasting by *C-D*; braking by *D-E* and the stop by *E-F*. Many times it is possible and convenient, where there are a large number of stops, to choose a

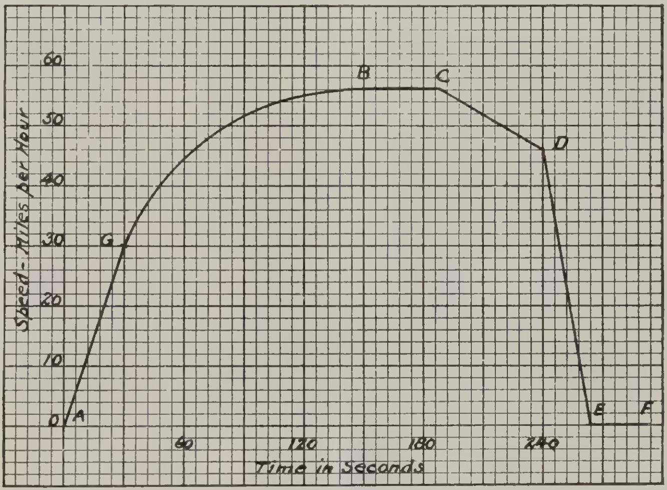


Fig. 4. A Typical Speed Time Curve Where the Average Length of Run Is 264 Seconds

typical run which will be the average of runs between each stop and will represent the conditions to be met by the electrical equipment. A typical run for a particular service where the average length of run, including stop, is 294 seconds, is represented by Fig. 1. When using this typical run, some grade must be assumed which will represent the average of all the grades. Even if the ends of the line are at the same elevation, energy is expended by the train running over the rolling country as all of the power stored by lifting the car is not available for coasting on the down grades. The equivalent grade represents the average grade and is obtained as follows:—

$$\text{Equivalent Grade (in per cent)} = \frac{100 \times \text{sum of rises in feet in both directions}}{2 \times \text{length of round trip in feet}}$$

Examples

The following examples have been assumed to show how the various values of train resistance, grade resistance, etc., are used and applied.

1. What tractive effort will be required to propel a 55-ton car up a 1.23 grade at 35 miles per hour?

To propel a 55-ton car at 35 miles per hour will require 15.6 lb. per ton (value obtained by referring to resistance curves Fig. 2) as train resistance.

$$55 \times 15.6 = 858 \text{ lb.}$$

To lift the car up the grade the lb. required—

$$55 \times (20 \times 1.23) = 1{,}353 \text{ lb.}$$

Ans.—858 + 1,353 = 2,211 lb. tractive effort.

2. What would be the required tractive effort if there was a 6 degree curve on this grade?

Assuming 0.8 lb. per ton as curve resistance per degree of curvature, the tractive effort account of the curve would be:

$$55 \times 0.8 \times 6 = 264$$

Ans.—Total T.E. = 2,211 + 264 = 2,475 lb.

3. What tractive effort required to accelerate at 0.6 m.p.h.p.s. on the above grade and curve?

The tractive effort to accelerate at the rate of 0.6 m.p.h.p.s. is:

$$55 \times 60 = 3{,}300$$

There will still be required the same tractive effort for the grade, curve and train resistance so that the total T.E.

Ans.—2,475 + 3,300 = 5,775 lb.

Horse-Power

Sometimes it is interesting to know what horse-power is developed by the locomotive when running. This is easily determined when the tractive effort and speed is known by the formula:

$$\text{H.P.} = \frac{\text{Pounds tractive effort} \times \text{miles per hour}}{375}$$

The railway motor has certain characteristics. For a specific motor there is a definite relation between the revolutions, the torque delivered by the motors, and the current consumed to deliver this torque. Characteristic curves are made up for railway motors, from which it is possible to work out just what the locomotive or car equipment will do in a certain service. Our next article on "Electric Traction" will discuss the different types of railway motor curves, direct current, single-phase, and three-phase. The article will explain how to read these curves so that the information contained can be applied to a definite problem. In connection with this discussion, the effect of change in gear ratio and voltage will be considered.

Electric Headlight Case

The Interstate Commerce Commission has taken under advisement, without comment, after all-day oral arguments on November 27, the controversy concerning the proposed rule to adopt high power locomotive headlights. The details of the hearings which were held on October 30 and 31 and November 1, 2 and 3, were reported in the *Railway Electrical Engineer* of November.

In the closing oral argument, Solicitor Charles C. Paulding of the New York Central, as chairman of a special committee including Duane E. Minard of the Erie and Stacy B. Lloyd of the Pennsylvania, declared that every contention of the carriers as to the danger and impracticability of the "searchlights" in many cases had been fully established and corroborated by a preponderance of the most credible testimony. He urged that the only proper rule for the commission to adopt would be to prescribe a reasonable minimum power for headlights, to be made capable of exact measurement by beam candle power, which would enable different railroads to adapt their headlights to the widely-varying conditions on different lines in different localities, which the testimony showed is essential to safe and efficient operation.

Grand Chief Warren S. Stone of the Brotherhood of Locomotive Engineers made the only argument for the electric headlights, speaking for two hours and citing the testimony of member engineers that they had had no trouble whatever in using the intense headlights on western roads, such as being blinded by the dazzling glare when trains meet, misreading of signals through false colors, phantom lights and reflections, as described by a score of engineers called by the carriers and testified to as the result of numerous tests. He insisted that the electric headlight should be considered a safety device.

Solicitor Paulding pressed the point upon the commission that what might be satisfactory and safe on one railroad might be impracticable and dangerous on another, because of the variance of local conditions, and that what can be used on the single-track lines in the sparsely-settled regions of the West might be utterly impossible on the multiple-track roads of the East and in the congested districts and suburbs around the big cities. He reviewed the voluminous testimony at length to support the insistent declaration of operating officials and many enginemen that the "searchlights" would be a serious menace to safe operation where traffic is dense and many trains are constantly passing one another at high speed on adjoining tracks, setting at naught the elaborate systems of block signals, through which safe operation has been achieved and the accurate operation of which depends upon correct reading of colored lights by engineers.

Attorney Lloyd made the closing argument, answering the plea of Grand Chief Stone, and briefs were filed by both sides.

Charges Violation of Penal Law

A sensational feature of Solicitor Paulding's vigorous argument was the statement that the brotherhood chiefs, in expelling engineers from membership for testifying to their belief that the electric headlights are dangerous, had violated the Federal Penal Code, which prescribes a fine of $5,000 and six years' imprisonment for intimidation or wrongful influencing of witnesses in a proceeding before a United States court or commissioner.

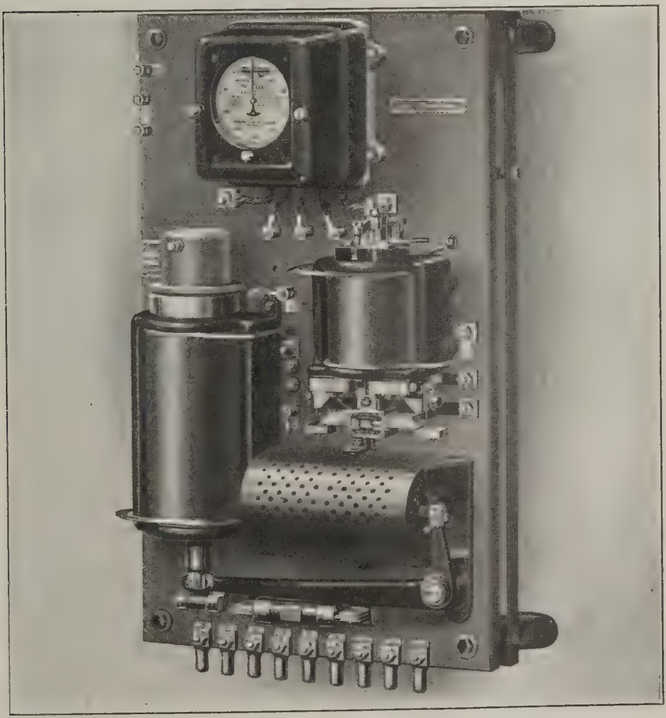
The railroads' counsel scathingly denounced the brotherhood constitution's provision providing that "any member who interferes with a legislative matter being conducted by the legislative board shall be expelled." He called attention to the warnings sent broadcast to engineers that they were subject to expulsion if they testified, and cited the case of David Trostle, an engineer who admitted under oath that while he was waiting to take the witness stand, Alonzo G. Pack, assistant chief inspector on the government staff of Frank McManamy, had "reminded him of the brotherhood rule that he could be expelled for interfering in legislative matters" even within the hearing chamber of the Interstate Commerce Commission. With the testimony of the brotherhood witnesses so directly contradictory of all the mass of testimony of engineers and others who testified of difficulties in vision through false colors, reflections and blinding glare from the high-power lights, as produced by the railroads, the two could not be reconciled and it resolved itself into a matter of the credibility of the witnesses, said Solicitor Paulding.

A. B. C. Car Lighting Course

Lesson No. 56

U-S-L Type C Panel

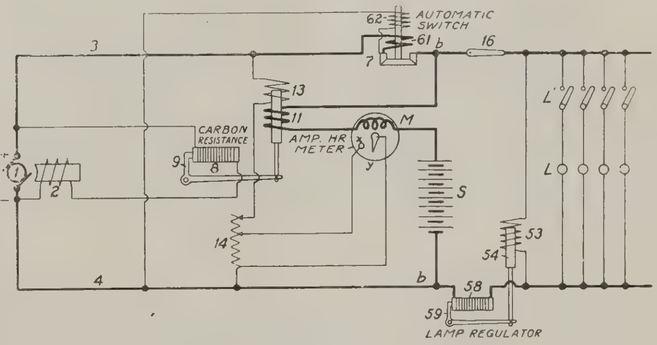
THE essential features of the U-S-L type C panel can be easily grasped by a study of the schematic diagram, which also illustrates the simplicity of the system. The shunt coil (62) closes the automatic switch and puts the generator in circuit when its voltage rises to the proper value; a resistance (not shown in the diagram) is then cut in the shunt coil circuit, and the switch is opened when the generator slows shown by reverse current in the series coil (61). The lamp regulator, which operates by varying the pressure on a carbon pile resistance, maintains constant potential on the lamps, independently of the condition of battery or generator. Generator regulation is effected by variation of the carbon pile resistance (8) in the shunt field circuit, and ampere hour meter control is used.



U-S-L Type C Panel

Battery Charging

The panel maintains "modified constant potential" regulation of the generator. The shunt coil of the regulator (13) is the principal factor in the regulation. Note that this shunt coil is in series with an adjustable resistance (14). The series coil, or modifying coil, modifies the potential regulating effect of coil 13; while coil 13 tends to operate the relay to maintain constant potential, the series coil (11) opposes this action and allows the generator voltage to rise as the charging current drops off when the battery approaches full charge.



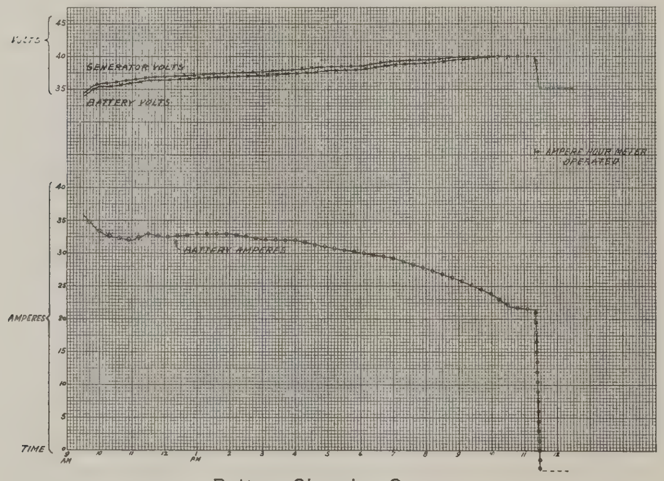
Schematic Diagram

The series coil (11) also reduces the voltage and prevents excessive current when charging a run-down battery.

With the culmination of full charge, the closing of the contact within the ampere hour meter short-circuits a portion of resistance (14), permitting greater energization of coil 13. The resulting increased magnetic pull on the plunger of the regulator increases the carbon pile resistance and reduces the generator voltage to "floating battery" value, which is about 35 volts. Thus, following meter closure, the battery neither receives nor delivers energy while the speed of the generator continues at or above the operative point, the battery merely floating on the system. During battery floating periods the generator regulation is straight constant potential.

The regulation curve, plotted in amperes and volts against time, shows evidence of the effectiveness of the control system. A feature of the operation is the fact that the turning on of any number of lamps has no effect on the charging current sent into the battery. The generator automatically "picks up" the lamp load in addition to the charging load. This is accomplished by arranging the connections so that only the battery current flows through the controlling coil 11. Referring to the schematic diagram on page 583 it will be noted that the lead to the positive side of the lamps is tapped to the lead going to the control coil 11 at *b* so that the lamp current is independent of the control current. If this tap had been made between coil 11 and the meter both lamp and battery current would have gone through the control coil 11 which would result in a reduced charge as lamps were turned on.

The U-S-L corporation emphasizes the operating economy in utilizing the high efficiency generator for carrying the lamp load, just as though no battery were used, during all periods in which the generator runs at or above operative speed; this direct lighting avoids the loss of energy that would otherwise be incident to the use of what they refer to "taxed current" drawn from the battery under the same condition of speed. The term "taxed current" refers to the fact that you must put from 15 to 20 per cent more energy into a battery than you can possibly get out of it. Considerable prolongation of battery life is also secured by minimizing the battery discharges; the more a battery is worked, the faster will be the evaporation and the greater the wear on the plates, measured by the mud deposit. The safeguarding of the battery charge by means of the ampere hour meter is a large factor in the improved operation.



Battery Charging Curves

Mechanical Details

The automatic switch is the old standard switch made for years by the U-S-L corporation. For a long time this company has made the insulating base for the short-circuiting finger at the top of the switch of molded bakelite, a material which now appears in several places on the panel. The dash pot and piston are both made of graphitized bakelite. The ring around the solenoid plunger is made of graphalloy, selected for easy slipping within the solenoid tube.

Concreting in Cold Weather

Concrete work can be carried on successfully in cold weather. All that is necessary is to heat the sand and pebbles or broken stone and mixing water so that the concrete mixture will have a certain minimum temperature, then to place the concrete quickly and maintain the heat until early hardening has been completed. This does not mean that there are no limitations to the practicability of doing concrete work in cold weather, but that if a few simple precautions and protective measures are used, winter concrete work will be as successful as that done in warm weather.

During the first few days following the placing of concrete, alternate freezing and thawing at comparatively short intervals will damage it. It is thus necessary to so mix, place and protect the concrete that early hardening will be complete before the work is exposed to freezing temperatures. To do this:

(1) Sand and pebbles or broken stone used must be free from frost or lumps of frozen material. (2) If these materials contain frost or frozen lumps, thaw them out before using. (3) As cement forms but a relatively small bulk in any batch of concrete, it need not be heated. (4) Mixing water should always be heated.

Although adding common salt to mixing water will prevent freezing of concrete that has not hardened, there is a limit to the quantity of salt which may be added if the final strength of the concrete is not to be affected. Salt simply lowers the freezing point of the mixing water; it does not supply what is most needed—heat and warmth. It delays, instead of hastens, the hardening of the concrete. Sand and pebbles or broken stone and mixing water must be heated so that the concrete when placed shall have a temperature of from 75 to 80 degrees. Some sands are injured by too much heat. The same applies to certain varieties of pebbles and broken stone. A temperature not exceeding 150 degrees Fahrenheit will generally prove most satisfactory. Place concrete immediately after mixing so that none of the heat will be lost before placing in the forms. Warm metal forms and reinforcing before placing concrete. Be careful to remove ice and snow and frozen concrete remaining on the forms from preceding work. Forms can be warmed by turning a jet of steam against them or by wetting with hot water. Even though materials have been heated and the concrete placed immediately after mixing, it will lose much of its heat if not protected from low temperatures.

Frozen concrete sometimes very closely resembles concrete that has thoroughly hardened. When frozen concrete is struck with a hammer, it will often ring like properly hardened concrete. Before removing forms, examine the work carefully to see whether it has hardened or is simply frozen. To determine this, remove one board from some section of a form, pour hot water on the concrete or turn the flame of a plumber's blow torch or a jet of steam under pressure against the concrete. If frozen, the heat will soften the concrete by thawing the water contained in it. Although concrete which freezes before early hardening has been completed may not be permanently injured, if after thawing out it is not again exposed to freezing until hardened, protecting the concrete against possibility of freezing is best.

Practical Stunts

Light for Night Work Under Cars

In a great many cases it is necessary to work at night on cars that are in need of electrical repairs, and it is not an uncommon occurence that the car or cars to be worked on are in an isolated position, and far from electric light lines. It often happens that it is impossible to use extension lights connected to any of the car circuits, owing to little charge being left in the car storage battery.

The use of kerosene lanterns is impracticable for two reasons, viz., the light given out by them is poor, and it necessitates the use of one man to hold and manipulate the light. Knowing these conditions, we built the apparatus shown in the photograph, which we believe is one solution of the problem.

The apparatus consists of a low voltage flood light connected by an extension line to the charging plug receptacle, with an adjustable resistance in series. The light consists of a 12-inch parabolic reflector in which is placed a 25 C. P., 6 volt, Mazda C. bulb, these being enclosed in a suitable weatherproof case, and the whole mounted on an adjustable tripod or stand. The connecting cable is a 5 foot length of No. 12 stranded R. C. deck cable to the end of which is connected an attachment plug. This plug fits one of two receptacles on the case which surrounds the resistance, and a similar plug from the battery cable leads to the other receptable. On the other end of the battery cable is a plug which fits the charging receptacle of the car.

The resistance coil itself consists of a length of German silver wire (No. 16 B. & S.) 72 feet long wound on an asbestos covered form, and having a sliding contact which makes it possible to adjust the voltage across the lamp terminals to its normal pressure regardless of whether the battery is fully charged or not. When adjusting the voltage in this manner care should be used not to put too high a voltage on the 6-volt lamp.

The light given by this apparatus is a powerful and steady ray. It is primarily intended to illuminate generators, under body lamp regulators and batteries, and fulfills the requirements very thoroughly. Two or more lights may be used by connecting them in parallel, and interposing the resistance between them, and the battery plug receptacle.

William L. Foss, Electrician,
Maine Central, Portland, Me.

Rack and Drip Pan for Painting Edison Batteries

When Edison batteries are dipped in paint, allowed to stand in the drip pan, then placed on the battery bench, considerable paint is spilled on the bench and floor, which means a waste of paint and endangers a man's safety from slipping while performing this work.

The arrangement shown in Fig. 1 consists of an iron paint tank, a rack made from angle iron with five flat iron crosspieces, and a drip pan made of galvanized iron shaped so as to drain the dripping paint back into the tank. After a full set of batteries (18 crates) has been dipped and placed on the rack as shown in Fig. 2, the porcelain skids on the wooden crates can be cleaned off with a cloth saturated with kerosene to cut the paint, before placing the batteries back on the bench.

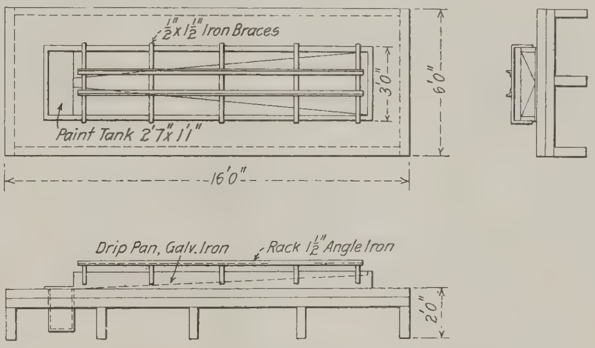


Fig. 1

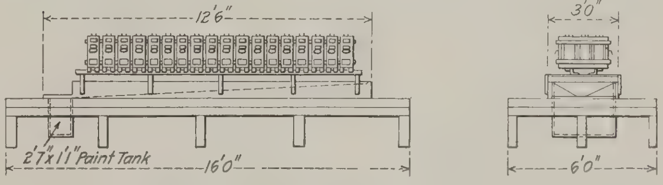


Fig. 2

This apparatus, when mounted on a bench 16 ft. long and 6 ft. wide, as shown in Fig. 1, will give ample room for a walk on each side of the rack.

Chas. W. T. Stuart, Electrician.
Penn. R. R., Philadelphia, Pa.

Improved Armature Pulley Puller

A short time ago I noticed a practical stunt where a pulley puller was constructed by using a nut with a bolt, the bolt being sawed off and center-punched. I believe that the pulley puller which I have been using for the last year is more practical as there are no loose nuts to be lost. The sketch in Fig. 1 shows the pulley puller assembled while Fig. 2 gives the details.

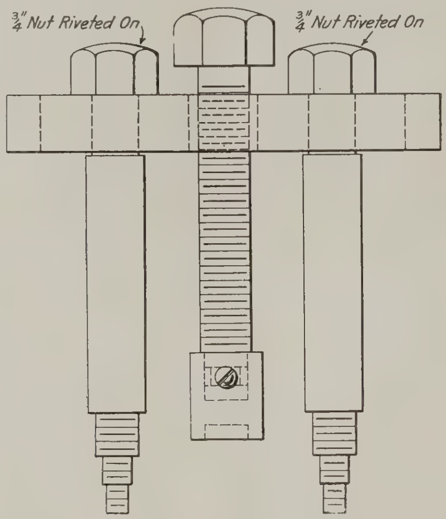


Fig. 1. The Pulley Puller Assembled Ready for Use

It will be noted that with the cap for the center bolt it is impossible to damage the center of armature shaft. This cap is turned out to ⅞ in. by ¼ in. deep which works all right on the U. S. L. equipments, but for some of the equipments that have a larger shaft end at armature pulley it would have to be enlarged to suit.

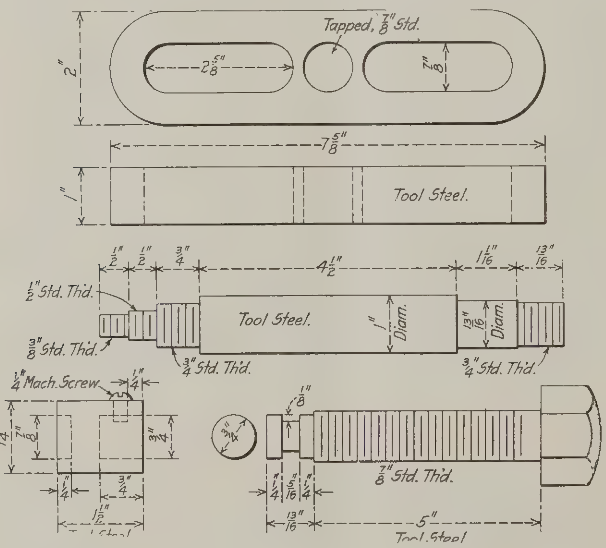


Fig. 2. Details of the Improved Pulley Puller

T. H. Hopkins, Foreman Electrical Dept.,
Oregon Short Line, Salt Lake City, Utah.

Lubrication of Relay Pivots

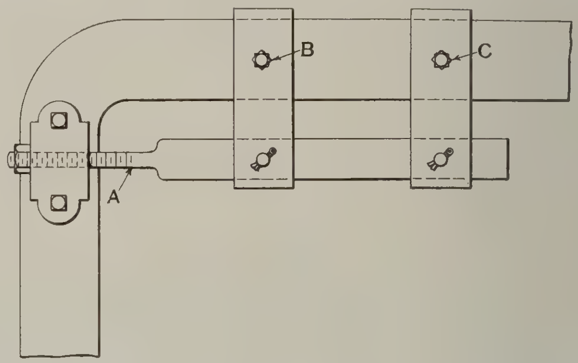
It is a well recognized fact that all pivots and pins acting as pivots on switchboard apparatus, etc., should be as nearly as possible devoid of friction; for this reason they are often made of phosphor bronze. It is not advisable to oil such parts for they might collect dust and form gum. Although phosphor bronze gives excellent results when kept clean, yet sooner or later it is bound to gum and stick.

This is especially true of the pin that holds the pole changer trip of a Gould simplex generator; also the pivots of safety automatic switches. My stunt is to coat all these pins with dry graphite after they have been thoroughly cleaned. If powdered graphite is not at hand, I rub the entire surface with a soft lead pencil, which has the same effect. It is surprising how much friction can be eliminated by this method, with resulting closer regulation of the apparatus.

E. C. Meilloret, Electrician,
Long Island Railroad.

Repairing Bliss Suspension

Space bars on the generator suspension of Bliss equipment become broken occasionally. When a car comes to the Frisco shops in this condition we cut off the threaded end of the space bar (*A*), drill and tap the thread for ¾ in. set screws and secure the set screws with lock nuts, (*B*) and (*C*). We find this much better than the original scheme.



L. J. Barclay,
Frisco Shops, Springfield, Mo.

Frontiersmen Welcome Electric Train

The Chicago, Milwaukee & St. Paul Railway is now electrified for a distance of 440 miles in Montana, over two mountain ranges from Harlowton, Mont., to Avery, Idaho. Through Missoula, near the western terminus of the electrified section, all regular freight and passenger trains are being drawn by electric locomotives and nearly all the extra trains are so handled also. A so-called "steamer" shows up once in a while, however, as the Chicago, Milwaukee & St. Paul has not received all of its electric engines from the General Electric Company.

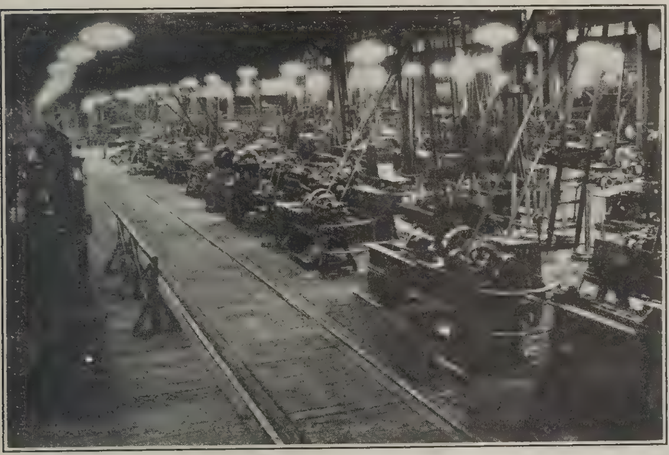
When the first passenger train drawn into Missoula over the Milwaukee arrived there was a good-sized crowd at the station. In that crowd were Granville Stuart, who discovered gold in Montana; E. S. Paxton, famous throughout the country as an Indian artist, and formerly an Indian fighter; Major Catlin, one of the leaders in the Indian wars, and Judge F. H. Woody, who arrived in what is now Missoula in 1856. All of this quartet came into Montana with bull teams, and each marveled at the progress of the age when he saw the first electric locomotive slide out from Hellgate Canyon, pulling its long line of steel coaches.—*Electric Railway Journal.*

New Device Section

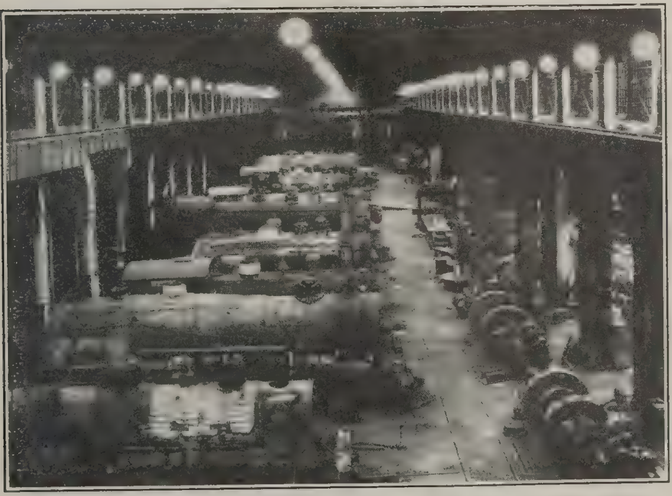
Modern Shop Lighting

An example of the best modern practice in shop illumination is to be found in the Ferguson (Ky.) shops of the Cincinnati, New Orleans & Texas Pacific Railway. The accompanying photographs illustrate the results secured in uniform lighting over large areas.

In the erecting and boiler shops, Benjamin elliptical angle reflectors are used with 500 watt Mazda C lamps mounted on side walls above crane tracks. The advantages of wall mounting include accessibility for cleaning and lamp renewals; better direction of light for illumination on vertical surfaces and the more hidden places on locomotives, and a striking absence of shadows and uniformity of lighting on the working plane. An average of four to five-foot candles intensity is obtained with 0.9 watt per sq. ft. of floor area.



Machine Shop.



Erecting and Boiler Shop.

In the machine shop, with a comparatively low ceiling, Benjamin shallow bowl reflectors are used with 100-watt Mazda lamps, mounted 10 to 14 ft. high and spaced at frequent intervals. This arrangement results in high intensity and uniform light on the working plane, and it is found that there is no need for drop cords or individual lights. The reflectors were supplied by the Benjamin Electric Manufacturing Company of Chicago.

Wiremold

Wiremold is a new form of metal conduit brought out by the American Conduit Manufacturing Company, Pittsburgh, Pa. Its assembly and installation call for no special tools, slots, holes or screws—it is simply cut into the required lengths and shoved over the coupling tongues of the fitting. It is provided with a finish which blends with the color of the average wall upon which it is used—a neutral-tone enamel.

Wiremold is made in the two wire sizes only—21/32 in. wide and 15/32 in. thick over all, and is designed for surface wiring exclusively. Wiremold base and capping is permanently assembled at the factory and conductors cannot be laid into it as in similar materials but must be fished in all cases. To install wiremold, push the coupling forward until the screw hole is clear and then attach to the wall with a number 8 flat head wood screw as shown in Fig. 1 (the coupling is the portion which contains the screw hole), then slip the next link over the edges of the coupling as shown in Fig. 2, and close up as shown in Fig. 3.

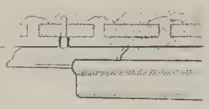


Fig. 1

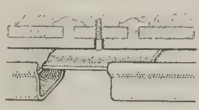


Fig. 2

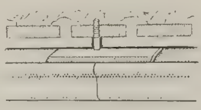


Fig. 3

The base plates of all wiremold and fittings of cross, tee and elbow types are provided with ribbed tongues, as can be seen from the broken end view of such a base plate as shown in Fig. 4. In coupling wiremold with fittings of this type, the tongues are slipped into the grooved edges of the molding as illustrated by Fig. 5.

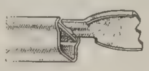


Fig. 4

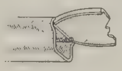
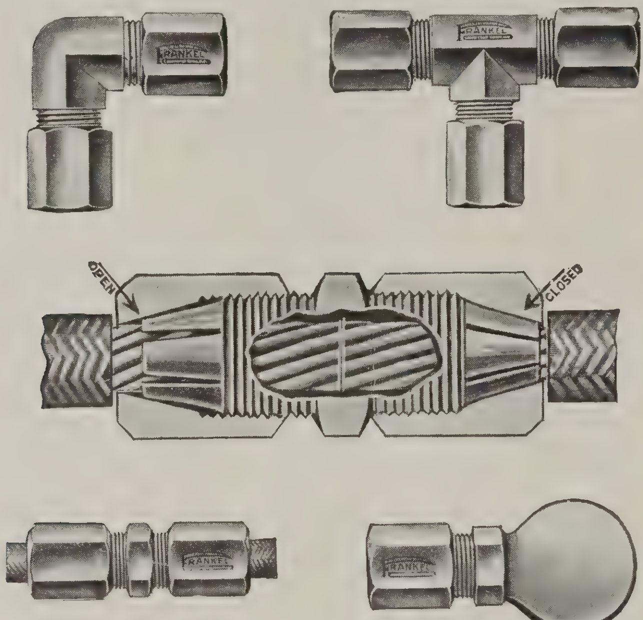


Fig. 5

Wiremold is well adapted to the wiring of old suburban cars, postal, baggage cars, etc., where it is not desired to conceal the wiring. It is also especially adapted for the rewiring of freight stations, second, third and fourth class passenger stations, docks, warehouses, etc., where it is considered desirable to replace the obsolete, dangerous, open wiring with a modern conduit installation.

Solderless Connectors

A new type of connector for stranded or solid wire is illustrated herewith. It is intended to make a better and cheaper joint than can be made by use of solder, for when the cost of time, solder and equipment is considered, it will frequently be found that a mechanical connection saves more than its own cost. Certified tests have proved that when a line is tested to failure by excessive current, a soldered lug melts and opens the circuit before the connector has suffered any damage, and the connector does not heat as much as the cables which it connects. The mechanical strength of such a joint is sufficient for ordinary strains, but an extra strong connector or splicing sleeve is made for trolley wire.



Frankel Solderless Connectors

These connectors are made for two-way and three-way joints, elbows, reducers, cable taps, and numerous special forms; they can be supplied with any standard finish. The connectors are made by the Frankel Connector Company, New York.

New Type of Wall Brackets

The illustrations show some new wall brackets and insulators which have been in service long enough to prove their value. A three-point bracket, consisting of a sherardized stamped steel base-plate on which are mounted porcelain insulators of a unique design is shown in Fig. 1. The method of mounting the insulator is shown by the phantom view in Fig. 2. It is not necessary to use tie wires on these insulators, but they may be used in the regular way if so desired. A corner chair, Fig. 3, is supplied for mounting a bracket on a corner of a building as shown in Fig. 4. They can also readily be attached to steel girders. The use of these fixtures improves greatly the appearance of a job compared to the old wooden brackets. These brackets, complete with insulators, are manufactured by the National Metal Molding Company, Pittsburgh, Pa.

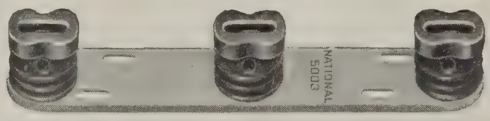


Fig. 1.

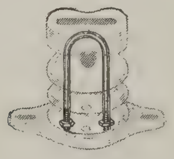


Fig. 2.

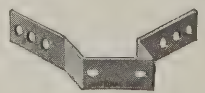


Fig. 3.

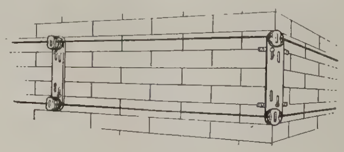


Fig. 4.

Flood Lighting Railroad Yards

The use of flood lights in railroad yards at night is a distinct advance toward the goal of safe working conditions. It will be noted in the illustrations that the lamps do not throw a defined and concentrated beam, but tend rather to spread the light uniformly over a considerable area and there is an entire absence of blinding effect even when looking toward the light. The lamps used are the Western Electric-Davis type, manufactured by the Western Electric Company, Chicago, Ill.

Flood Lighting Passenger Yard

Engine Terminal Illuminated by Flood Lights

General News Section

The Adams-Bagnall Electric Company, of Cleveland, Ohio, manufacturers of "Abolite" enameled reflectors, is completing an addition to its factory by the installation of a complete porcelain enameling plant.

Pass & Seymour, Inc., have announced plans for investing $225,000 in making additions to their plant at Solvay, N. Y. These additions when completed will add about five hundred persons to the pay roll.

The New York Central has filed an application with the Second District Public Service Commission in regard to the New York Central Railroad Equipment Trust of 1917. It proposes to purchase rolling stock to the value of $15,000,000, included in which are 30 multiple unit motor cars and ten electric locomotives.

The Westinghouse Electric & Manufacturing Co. reports the receipt of a contract from the New York Connecting Railway, New York city, for all the catenary hangers to be used in its construction. This four track railroad, connecting the New York terminals of the Pennsylvania and New Haven lines, is being equipped for 11,000 volt single phase operation.

The New York, New Haven & Hartford, on the occasion of the Yale-Harvard football game on Saturday, November 25, carried into New Haven, in the space of 3 hours 11 minutes, 32,423 passengers; and it is reported that from 8,000 to 10,000 visitors had arrived in New Haven on the day before. On Saturday the number of trains carrying passengers from New York to New Haven in the morning was 31, and the number of passengers 18,108. The trains ran through, 74 miles, in two hours. The passengers leaving New Haven Saturday afternoon numbered 33,779, and they traveled on 71 trains, starting between 4 p. m. and midnight. Practically all the New York trains were hauled over the entire distance by electric power, the New Haven using its electric freight locomotives to help handle the rush.

New York Car Lighting Club

An example of a live car-lighting club in action was given on Tuesday evening, November 14, when about forty members of the New York association left the Grand Central with Mr. Wall, president of the association, met Secretary J. M. Scudder with about twenty more at Brooklyn bridge, and proceeded to the Brooklyn plant of the Franklin Railway Supply Company. Some interesting observations were made en route on the battery lighting system of the new Brooklyn subway cars, which came into action quite frequently as the shoes passed over breaks in the third rail. Arrival at the destination was a half hour ahead of time, probably under the impression that the equipment must be in operation by the schedule time of nine-thirty. The extra half hour was appreciated however, when H. D. Rohman was explaining the fine points of the Stone-Franklin car lighting system. The equipment easily demonstrated its ability to do all that was expected of it, and Mr. Rohman was voted a royal entertainer.

The next meeting, held in the Grand Central Terminal on Tuesday, December 5, was devoted to a discussion of Stone-Franklin equipment, Mr. Rohman of the Franklin Railway Supply Company being present to answer questions.

Proposed Electrification on the D. & R. G.

Engineers of the Denver & Rio Grande Railway have completed surveys and estimates for the Soldier Summit grades, and plans will be submitted to H. U. Mudge, president of the railroad, who will make recommendations to the board of directors concerning the change from steam to electrical operation on the grades over the Wasatch Mountains. The building of a high-tension line by the Utah Power & Light Company from Provo to Price is said to be the first step in the proposed electrification. It is understood that the cost of power is now being estimated by the Utah company and that contracts may be tentatively entered into within the next few weeks.—*Journal of Electricity, Power and Gas.*

Hess-Bright Not Controlled by Outsiders

To correct misleading rumors and statements The Hess-Bright Manufacturing Company makes the following announcement:

A group of bankers, including Frank A. Vanderlip, Philip W. Henry, Thatcher M. Brown, and Franklin B. Kirkbride, of New York, and Marcus Wallenberg, of Stockholm, have recently acquired from the American group of stockholders a controlling interest in the shares of The Hess-Bright Manufacturing Company. This group of bankers owns also a substantial interest in the S. K. F. Ball Bearing Company of Hartford, Conn.

The two companies will be operated quite independently of each other. The former policy of The Hess-Bright Manufacturing Company will be continued except that its manufacturing facilities will be increased somewhat more rapidly to meet the constantly growing demand for its product. B. D. Gray, who retains his former stock holdings, will continue to manage the business as president. F. E. Bright retires from active participation in the company's affairs, but remains identified with the company as chairman of the board. Aside from these two changes, the organization remains as before.

Westinghouse Electric Grants Bonus

Announcement has been made by the Westinghouse Electric & Mfg. Company of an extension of its present bonus system to include salaried men and office employees on hourly rates, by which an employee will receive a bonus of 8 per cent of his salary each month, providing his total excusable time absent and late during the month does not exceed six hours, incurred on not over three occasions. An additional four per cent will be given each month to an employee who has not lost any time from work during the month through absence or tardiness, thus enabling him to obtain an increase in earnings of twelve per cent for a 100 per cent attendance. Several thousand employees in the Pittsburgh district are benefitted by the granting of the bonus.

Call for Back Copies

There is a demand for several copies of the *Railway Electrical Engineer* for each of the following dates: July, August, September and November, 1915. Twenty-five cents will be paid for each of the above copies up to the number required. If you can let us have any of these, please communicate with the editor.

Personals

Horace N. Trumbull has been appointed advertising manager of the S K F Ball Bearing Company, of Hartford, Connecticut.

Arthur V. Farr, who for the past three years has been advertising manager of the S K F Ball Bearing Company, Hartford, Connecticut, has accepted the position of sales manager of the Hess Steel Corporation of Baltimore, Md.

F. B. Gleason, formerly in charge of the far east business of the Western Electric Company at Tokyo, Japan, has been appointed manager of the southern district with headquarters at Atlanta, Ga., succeeding E. J. Wallis, who becomes manager of the Pacific coast district at San Francisco. Mr. Wallis will succeed F. H. Leggett, who, after three years on the coast, returns to the executive offices at 195 Broadway, New York City.

George H. Groce has left the Electric Storage Battery Company, where he has been a sales agent of the railway department, to become a sales representative in the railroad department of the U. S. Light & Heat Corporation of Niagara Falls, N. Y., with headquarters at 1402 Railway Exchange building, Chicago. Mr. Groce has had considerable railroad experience. Starting as a telegraph operator on the Pittsburgh & Lake Erie in 1880, he has since been with a number of roads in such positions as train despatcher, signal engineer, division superintendent and assistant to vice-president and to general manager. Mr. Groce has also represented the General Railway Signal Company, and was assistant to the president of that company. From 1912 to 1915 he was vice-president of the Wright Telegraphic Typewriter Company.

James H. Whitaker, assistant superintendent of distribution of the Puget Sound Traction, Light & Power Company, Seattle, Wash., is dead at the age of sixty-three. Mr. Whitaker was born in Illinois on February 19, 1853. In 1895 he went to St. Paul as manager of the Northwest Engineering Company. He remained in St. Paul for fourteen years. He then joined the electrical engineering forces of the Northern Pacific Railroad, which connection brought him to the Pacific coast. He resigned from the Northern Pacific Railroad to become city electrician of Tacoma and later entered the employ of the Seattle-Tacoma Power Company, with which company he was connected at the time of its absorption by the Puget Sound Traction, Light & Power Company.

Trade Publications

Arc Welding is the title of a 38-page booklet issued by the Arc Welding Machine Company, New York. Gas and arc welding are compared, as are also different systems of arc welding. The book is well illustrated and artistically arranged.

Electrical Supplies.—The Central Electric Company has published an attractive new catalogue which contains over 1,400 pages, though it is compact and not heavy, being printed on thin paper. The appendix gives, in addition to wire tables, engineering data, etc., complete National Electrical Code regulations covering wiring.

Cut Your Repair Costs.—The scope of arc welding work and the advantages accruing from the use of this process in railroad shops is concisely told in an interesting little booklet of the above title being distributed by the Westinghouse Electric & Mfg. Company of Pittsburgh, Pa. In addition to outlining some of the points to bear in mind when selecting arc welding equipment a number of examples are given, taken from actual shop records, showing comparisons in the cost of making repairs by the electric arc and by older methods, greatly to the advantage of the former. For instance, a case is cited where a cracked crown sheet was welded by the electric arc process at a total cost of 36 cents, and in one hour's time. By older methods it is estimated the cost would have been $75, and it would have taken 30 hours.

Electric Railway Apparatus.—Recent bulletins from the Westinghouse Electric & Manufacturing Company include circular No. 1516-A covering electric locomotives for freight haulage. It gives reasons for the adoption of electric locomotives, takes up the handling of freight traffic by electric railways, and contains a detailed description of the equipment used in such work as well as the Interstate Commerce Commission requirements for this service. The bulletin is well illustrated.

New Books

New Course in Practical Mathematics. Prepared by J. H. Wickman, general foreman, electrical department, Illinois Central Railroad. Comprised in several typewritten and paper bound volumes. Price $1.00 per lesson.

Mr. Wickman has prepared a series of four lessons on arithmetic, algebra and practical mechanics, and a further series on elementary electricity for shop electricians. The material is condensed but understandable and should be found very useful by the shop man who wishes to improve his knowledge of such subjects.

Electrical Tables and Engineering Data. By Henry C. Horstmann and Victor H. Tousley. 329 pages, 33 illustrations, 5 in. x 7 in. Bound in cloth. Published by Frederick J. Drake & Co., Chicago.

The book is intended to furnish those interested in electrical work with a reference and table book which can be conveniently carried in the pocket. It contains no theoretical discussions. Its scope is limited to practical information which is daily called for but seldom available at the time most needed.

Railway eng.

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RAILWAY ELECTRICAL ENGINEER

VOLUME 7 NUMBER 19

NEW YORK: Woolworth Building
CHICAGO: Transportation Building

December, 1916

CLEVELAND: Citizens Building
WASHINGTON: Home Life Bldg.

Merry Christmas To You

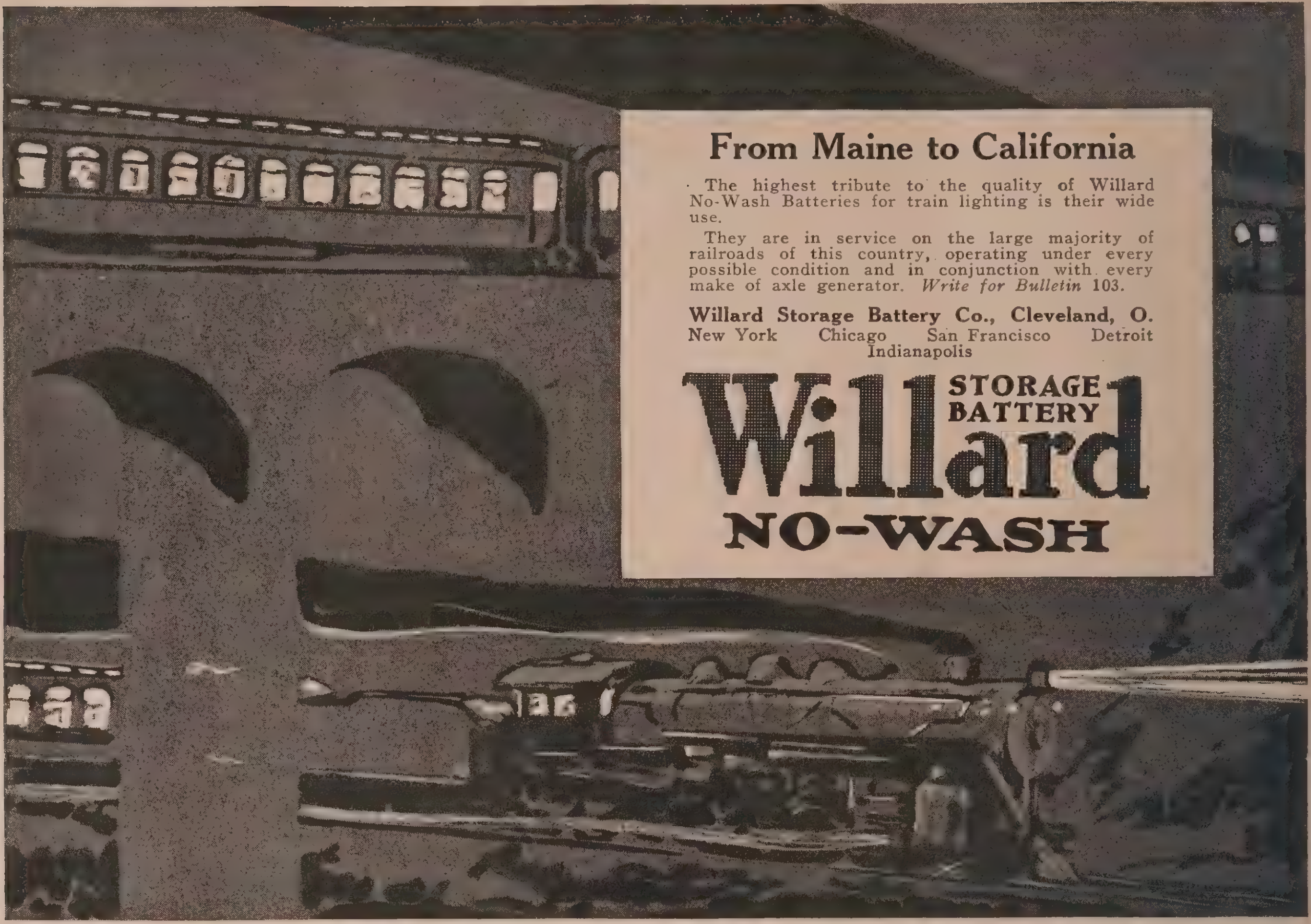
A happy New Year and a prosperous one, to you one and all. Should troubles come, as troubles do, may they disappear as quickly and surely as bearing troubles always do once you install

SKF BALL BEARINGS

Greetings to you all, greetings bearing a message of Peace and Efficiency through the use of S.K.F. Ball Bearings.

SKF BALL BEARING CO.

HARTFORD 12-16-R-EE CONN.



From Maine to California

The highest tribute to the quality of Willard No-Wash Batteries for train lighting is their wide use.

They are in service on the large majority of railroads of this country, operating under every possible condition and in conjunction with every make of axle generator. *Write for Bulletin* 103.

Willard Storage Battery Co., Cleveland, O.
New York Chicago San Francisco Detroit
Indianapolis

Willard STORAGE BATTERY
NO-WASH

Roads with highest belt mileage and lowest belt cost per thousand car miles use

GOODRICH
Axle Lighting Belt

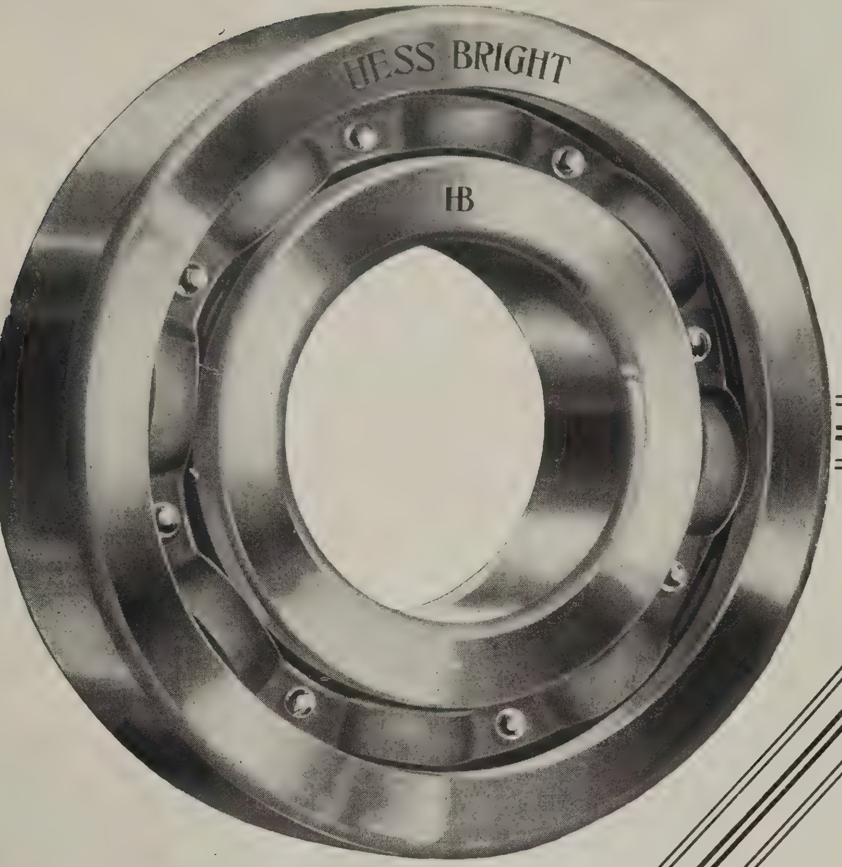
With but one exception, all railroads included in the Annual Report of the Committee on Data and Information having an average belt mileage in excess of 26,000 miles, are users of Goodrich Axle Lighting Belt. This report shown in the supplement of the October issue of Railway Electrical Engineer.

The reason for this uniform high type of service lies in the fact that into Goodrich Axle Lighting Belt, as well as into all our standard material for railroad service, goes our good name and the accumulative knowledge of 47 years of rubber manufacturing. May we help build greater mileage records for you?

The B. F. Goodrich Company

Makers of the Celebrated Goodrich Automobile Tires—
***"Best in the Long Run"*—and Everything That's Best in Rubber Goods**

Representatives Everywhere TRADE MARK **Factories: Akron, Ohio**



HESS-BRIGHT

The Inimitable Bearing

For Axle Generators

IN every line there is some one product of proxed excellence to which all similar articles are compared—and by that comparison judged and valued. One of the many distinguishing and meritorious features of a HESS-BRIGHT BALL BEARING is its *exceedingly deep ball races.* It invites comparison in this feature alone. These deep ball races are obtained, not by lessening the thickness of the rings at the bottom of the ball tracks—but by increasing the radial width of the race sides. This means ample material in the cross section of the rings, making them very stiff and strong.

Hess-Bright's Conrad Patents are thoroughly adjudicated

TRADE MARK
HB DWF
HESS-BRIGHT
THE INIMITABLE BEARING

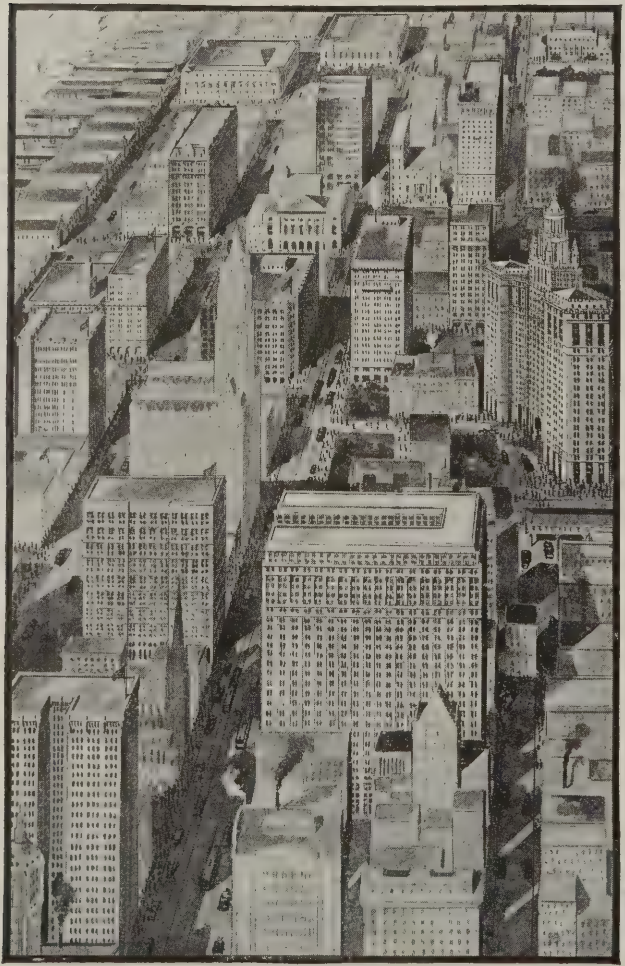
THE HESS-BRIGHT MFG. CO.

Front St. and Erie Ave. PHILADELPHIA, PA.

NATIONAL MAZDA C HEADLIGHT LAMPS

Over 4000 locomotives are already equipped with MAZDA headlight lamps. They throw an absolutely steady flood of light on the roadway far ahead—an easily controlled powerful beam of light without a flicker. National MAZDA headlights have no delicate mechanism. There is no cleaning, no trimming. They meet all reasonable state legislation. For more data address

NATIONAL LAMP WORKS
OF GENERAL ELECTRIC CO.
NELA PARK CLEVELAND



Representative Buildings of New York City In Which

SHERARDUCT

Sherardized Rigid Steel Conduit

was used exclusively. The buildings represented in this composite picture are as listed. Write today for Catalog and samples of **SHERARDUCT.**

- Adams Express Building
- B. Altman & Co. Store
- Architects Building
- Auto'b'e Club of America
- Chelsea Piers
- Globe Theatre
- Equitable Building
- Foster Building
- Yale Club
- H. C. Frick Residence
- Harvard Club
- Johnson Building
- Metro'l'n Museum of Art
- Municipal Building
- New York Postoffice
- New York Teleph. Bldg.
- Telephone & Tele. Bldg.
- 334 Fourth Avenue

National Metal Molding Co
Manufacturers of
Electrical Conduits & Fittings
11 Fulton Building, PITTSBURGH, PA.

Boston, New York, Chicago, Atlanta, Denver, Los Angeles, Portland, Seattle, Buffalo, Detroit, San Francisco S-17

The Causes and the Meaning of Noise in Ball Bearings

As you well know, noise in a machine is usually a danger signal. In bearings, it indicates the presence of looseness and friction that shouldn't be there. And friction, you know, means wear.

In ball bearings—which are supposed to be almost frictionless—noise is a sure sign of trouble a-brewing. Stop that noise at once—or you'll soon have to get a new bearing.

Noise results from vibration. Vibration comes—in a ball bearing—from looseness of component parts; from too much play; from imperfectly finished races; from imperfect balls; sliding friction where rolling friction is supposed to be; from loose mounting of the bearing; and from other causes. Look out for all these—they're dangerous.

The fit of the bearing in the housing and upon the shaft is also of importance in the reduction of noise. Tight fits—rigid mounting of both races—eliminate looseness. Your question is—rigid mounting, or floating mounting?

Then, there are many types of ball retainers or cages that, in the very nature of things, are bound to create noisy conditions. Study the cage proposition and you'll know why—you'll know that a noisy bearing is a wearing, inefficient bearing.

Finally, the way a bearing is put together—the fit of the parts—their dimensional accuracy or otherwise—the way it is, or must be, mounted and assembled—the way the parts are retained (all points of design and workmanship)—determine whether that bearing is going to be noisy or to run quietly.

Consider now, Neighbor, the "NORMA" Ball Bearing from this standpoint of noise or silence.

In the "NORMA" Bearing it is almost impossible (except under misuse and abuse) to create conditions where sliding friction exists—Point One for "NORMA" Silence.

"NORMA" ball races must be rigidly mounted, outer race held tightly in the housing and inner race held without any chance of movement on the shaft. This eliminates all chance for vibration between bearing races and machine parts—Point Two for "NORMA" Silence.

"NORMA" ball cages yieldingly hold the balls at the extremities of the axis of ball rotation with a light elastic pressure and with a very small contact surface. Friction between balls and cage is minimized and vibration here absolutely prohibited—Point Three for "NORMA" Silence.

The parts of "NORMA" Bearings are uniformly made to the highest degree of dimensional precision. This means absolutely correct relations of those parts within the bearing—perfect freedom of movement without the narrow excess of freedom which permits vibration, or chattering—Point Four for "NORMA" Silence.

And then, the materials used in "NORMA" Bearings are so carefully selected in the light of bearing requirements and so carefully treated, as to give maximum resistance to every wearing tendency which might destroy the perfect relation of parts—Point Five for "NORMA" Silence.

Now, let's get right down to brass tacks!

You want your bearings to last. They never will, if they're noisy.

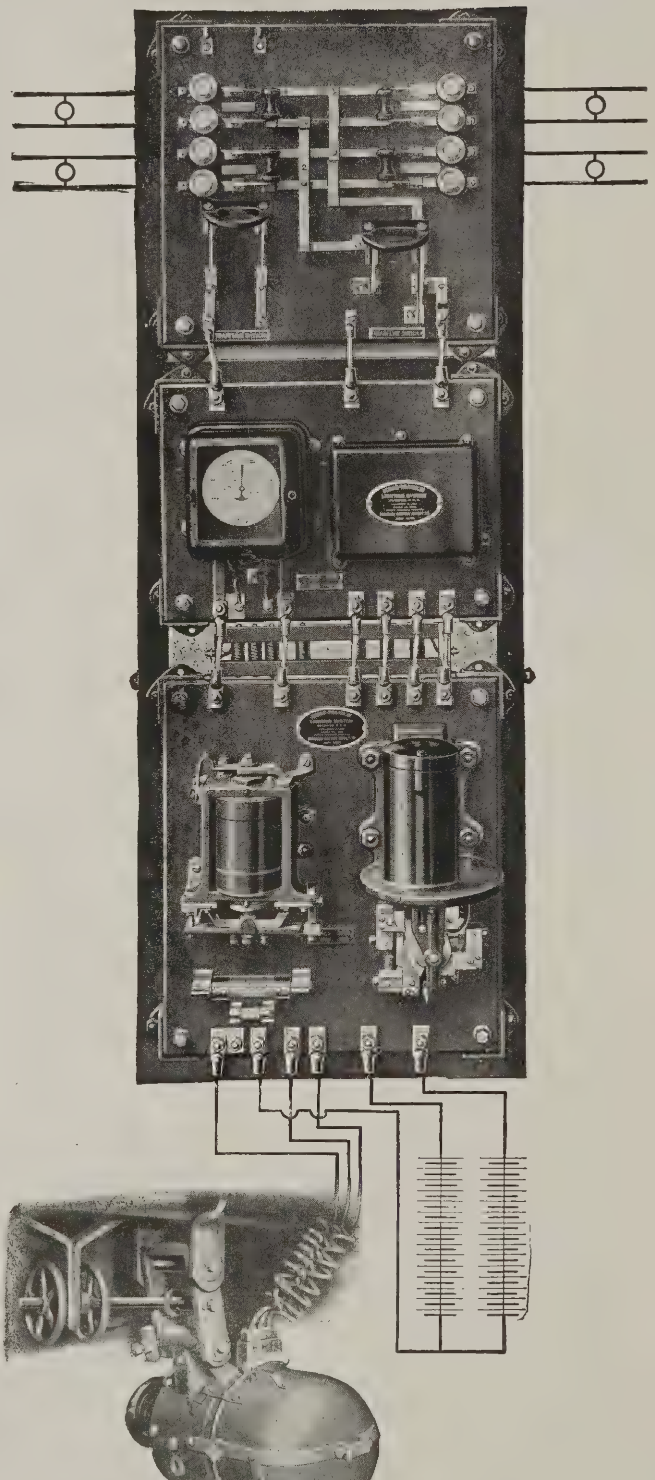
You probably want them to run at high speed. They can't—for very long—if they're noisy.

You want them to run true, and keep alignment and adjustment. They can't—if they're loose—for that means they're noisy; which, in turn, means they're wearing.

What's the answer? Use "NORMA" Silent-Running, High-Precision Ball Bearings. Our Engineering Department is anxious to show you how.

THE NORMA COMPANY OF AMERICA
1790 BROADWAY NEW YORK

BALL, ROLLER, THRUST, COMBINATION BEARINGS



REASON
FOR
STONE-FRANKLIN
SUCCESS

STONE-FRANKLIN CAR LIGHTING EQUIPMENT is a complete generating station.

It is built on the same lines and employs the same principles as the stationary power plant.

Controlled generator speed puts STONE-FRANKLIN into the stationary power plant class.

Mechanically regulated throughout, use of electrical regulating devices is avoided.

Reliability in service and low maintenance cost explain its increasing popularity.

Franklin Railway Supply Co.
30 Church St., New York

332 So. Michigan Ave.
Chicago

Transportation Bldg.
Montreal

Battery Bill and the Baggage Master

"Somewhere on the Road"

Dear Boss:

Cold here last night. Little sluggish when I gets off the downy couch this A.M. Exercised a bit while dressing and soon got up full speed; for like the Edison Storage Battery, the severest cold don't do me any permanent injury.

Tried to connect with the Purchasing Agent. Found he was out. Heard he was looking for me though. Rather size it up that the President's "Why aren't we using Edison Storage Batteries?" had got down his way. He had left word, however, that if I honored him, to wise me that he would see me tomorrow at ten. Will I be there? Rather!

Nothing to do, so dropped down to the station to see my friend, Jim, the Baggage Master. Some busy boy that; big convention leaving town, trunks, etc., something fierce. He was having his troubles getting things off his hands and on their way.

Ah Sid Battery was there on a truck, trying to tell them why their electric battery trucks weren't on the job. "Jim," says I kindly like, "the answer why those trucks of yours aren't tangoing down the platform is simple; it's the same old trouble -- battery trouble. I am not knocking any one," says I, "but just for information paste this in your hat. With Edison Storage Battery equipment you get what you want, where you want it, when you want it. The Edison is built for service that's why."

Then I adds, loud-like, so Ah Sid could get it: "Pickle jars on the tables of the diner are all right, but on a truck they certainly do jar one's nerves when the busy time comes."

"Good bye boys," says I."I'll try to get down after supper to see if those trucks of yours know today is moving day."

Air kinder salty here, but salty air don't worry

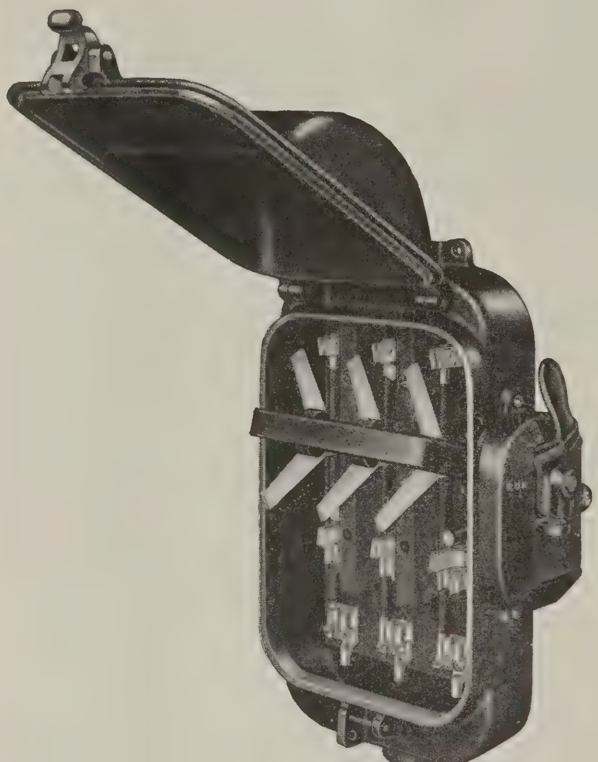
Yours for life,

Battery Bill

"Edison Storage Batteries for Baggage Trucks, Industrial Trucks, Locomotives and Tractors" is a little book of interest to the Railroad official who is interested in having his trucks always on the go. Battery Bill has mentioned a few points in their favor, all points are covered in this book. Yours for the asking.

EDISON STORAGE BATTERY CO.
Factory and Main Office: Orange, N. J.
Distributors in
New York Chicago San Francisco Seattle
Boston Detroit Los Angeles New Orleans

Motor Starting Switch Condulets



Type MFC—Door Open

Iron Clad and Fool Proof

Switch cannot be thrown from OFF to RUNNING position without first being put into STARTING position.

Padlocks can be used to lock the door shut and to fasten switch handle, so that it cannot be moved from position.

All parts are constructed to stand up under rough usage.

These Condulets are made for all sizes of conduit and for various arrangements of same.

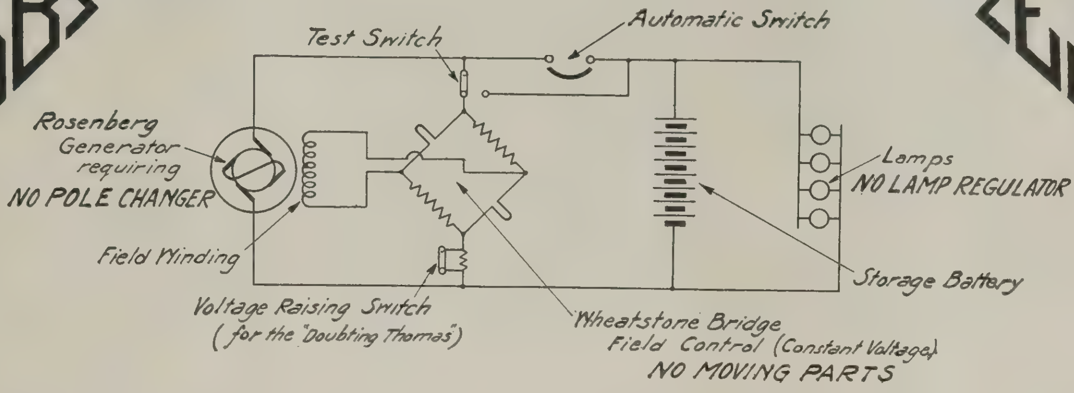
Special Bulletin, No. 1000 D, has been issued on these Condulets. A copy will be mailed free upon request to any address.

Type MFC—Door Closed

CROUSE-HINDS COMPANY

SYRACUSE, N. Y., U. S. A.

NEW YORK BOSTON CINCINNATI CHICAGO


Test Switch
Automatic Switch
Rosenberg Generator requiring NO POLE CHANGER
Field Winding
Voltage Raising Switch (for the "Doubting Thomas")
Wheatstone Bridge Field Control (Constant Voltage) NO MOVING PARTS
Storage Battery
Lamps NO LAMP REGULATOR

What Is Accomplished With Half A Watt

Last month we explained some of the advantages of *The E. S. B. Constant Voltage Control* and emphasized the importance of the *accuracy* secured by the Wheatstone Bridge Field Control of the

E. S. B. Constant Voltage Axle Lighting System

This month we will point out one of the reasons for this accuracy,—viz.:—that the E. S. B. 3 K. W. generator requires a maximum of only half a watt for its shunt field excitation.

Compare this with the large and *uncertain* amount of energy required to compress a carbon-pile or overcome the friction of pivots, dash-pots, etc., or excite the circuit of a large electromagnet. It is like comparing the accuracy of the watchmaker's implements with that of the blacksmith's tools.

Accuracy of voltage control depends upon the power required to effect that control.

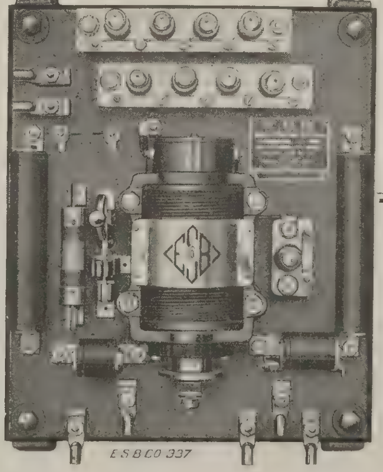
In the E. S. B. system this is only half a watt at the maximum and *less than one-tenth of a watt* under normal operating conditions.

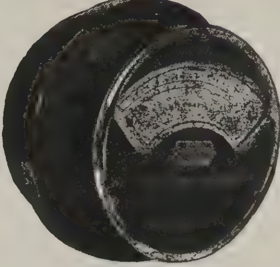
Hence the greater accuracy of the E. S. B. Constant Voltage Control.

More about the E. S. B. System next month

THE ELECTRIC STORAGE BATTERY CO.
Manufacturer of
The "Chloride-Accumulator", The "Tudor Accumulator",
The "Exide", "Hycap-Exide", "Thin-Exide" and "Ironclad-Exide" Batteries

New York Boston Chicago Washington PHILADELPHIA, PA. Detroit Denver San Francisco St. Louis
Cleveland Atlanta Pittsburgh 1888-1916 Minneapolis Rochester Toronto





The Art of Electrical Measurement, its perfection and its growth, have been associated inseparably with this name—

Weston

From the year 1888 to now, each successive instrument that has borne the name has marked the highest achievement in the Art.

At no time has Weston superiority been more obvious than in the present models.

The Weston A.C. Round Pattern Switchboard Group includes Ammeters, Voltmeters, Wattmeters (Single and Polyphase), Power Factor Meters, Frequency Meters and Synchroscopes.

These instruments have points of marked superiority over any others intended for the same purpose. Besides their extreme accuracy and serviceability, they are highly desirable for their uniformity of size and style, the openness of their scales and their legibility from any angle.

Weston Indicating Instruments include a great variety of groups for portable or switchboard service on A.C. or D.C. Circuits, Instruments designed expressly for testing and laboratory use, for motor car and boat electrical systems, and many others for special purposes. Write for Bulletins or Catalogs describing those which interest you.

Weston Electrical Instrument Co. 93 Weston Ave., Newark, N. J.

23 Branch Offices in the Larger Cities

STANDARD OF CANADA "STANDARD" QUALITY STANDARD OF CANADA

The quality that wins

in your service is that which makes for reliability and durability.

Our 35 years' experience in the manufacture of high-grade electric wire, together with most exacting service tests, gives to

STANDARD
Colonial Copper Clad Wire
30% TRADE C.C.C. MARK 40%

a guarantee of quality that removes it from the expensive experimental class of new and untried products. It stands among copper-clad wires as E. B. B. does among iron wires—for *extra best best* in quality.

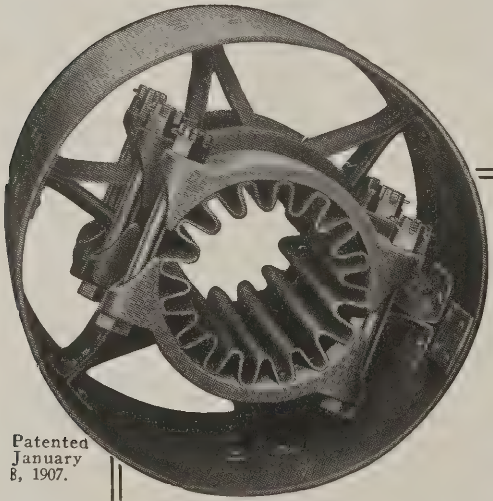
Will you allow us to send you the proof? Write our nearest office for a copy of Bulletin 202.

Standard Underground Cable Co.
Pittsburgh, Pa.

New York Philadelphia Chicago
Boston San Francisco St. Louis

For Canada: Standard Underground Cable Co. of Canada, Limited, Hamilton, Ont.

STANDARD OF CANADA "STANDARD" ECONOMY STANDARD OF CANADA



Patented January 8, 1907.

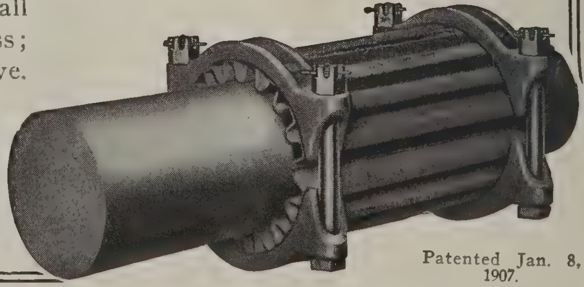
Jolt-Jar-Vibration Proof!

The real test of a pulley is actual service; the severe service that goes with axle car lighting equipment. Jolts, jars, and vibration that test its ability to grip; that test its dependability when snow, sleet and ice hold everything in their grip. Railway car lighting experts are agreed that the

Keystone Pulley with Oneida Corrugated Bushings

is the solution of the pulley problem; for no matter whether your axle is straight or tapered, Oneida Corrugated Steel Bushings grip at all times, in all kinds of weather. Made flanged or flangeless; standard 7½-in. bore; 16-23 in. diameter inclusive. Complete details on request.

Oneida Steel Pulley Company
ONEIDA N. Y., U. S. A.
Originators of Steel Railroad Pulleys and Steel Corrugated Bushings



Patented Jan. 8, 1907.

Protects Your Batteries

Insures Efficient Car Lighting

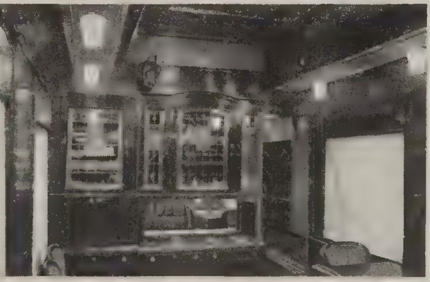
In nearly every case where car-lighting experts complain about lighting troubles, the battery is the cause. In other words, the heart of the axle generator equipment, is the battery; upon its efficiency at all times under all conditions depends the efficiency of your lights. To secure the best results the battery must be operated over the top range of its capacity. To hold it at its top range, to protect it from overcharging, every axle generator equipment needs the

SANGAMO
BUILT LIKE A WATCH
SANGAMO
AMPEREHOUR METER

It not only protects the battery, but its use insures uniform battery life of 8 to 10 years in all classes of service instead of 1 to 3 years as at present. Furthermore, its use will make battery flushing periods once in six months instead of once every two weeks.

Car-lighting experts are agreed that troubles have been due to overcharging. On over 6000 car lighting equipments, the Amperehour Meter control has demonstrated its ability to eliminate damaging overcharges, and yet keep the battery in first class condition so that it delivers over the top range of its capacity.

Let us send a copy of "RECENT IMPROVEMENT IN THE CONSTRUCTION OF AMPEREHOUR METERS."



Sangamo Electric Company
Springfield, Illinois

Specialists in Meters for Every Electrical Need

Speaking of Large Lamps that hang high

The Output of a Reflector

is in proportion to the cleanliness of its reflecting surface.

Now comes the

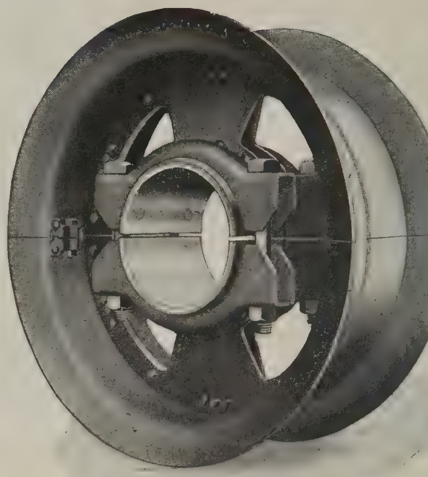
Human Factor

the natural tendency to neglect or avoid things difficult or dangerous.

How to make lamp cleaning *Easy* and *Safe,* and GET the OUTPUT from your REFLECTORS

Ask

The Thompson Electric Co.
5606 Euclid Ave. Cleveland, Ohio



Here is a new AMERICAN Steel Split Axle PULLEY. Its halves—that is, arms and rim—are in a single piece and the safety flanges are flared for greater belt play.

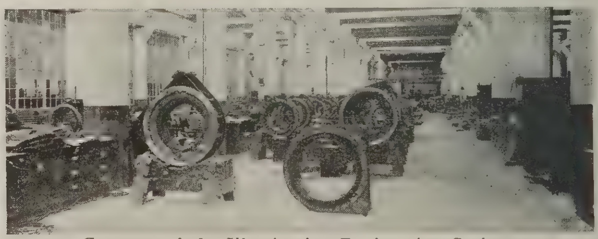
AMERICAN STEEL SPLIT AXLE PULLEYS

are fitted with interchangeable bushings, which makes them instantly available for straight or tapered axles of several sizes within a certain range. They can be applied easily without removing the wheels from the truck or raising the car body.

Full information will be sent on request.

AMERICAN PULLEY COMPANY
4230-60 Wissahickon Avenue, Philadelphia, U. S. A.
New York Chicago Boston Seattle

The Satisfactory Solution of a Lighting Problem



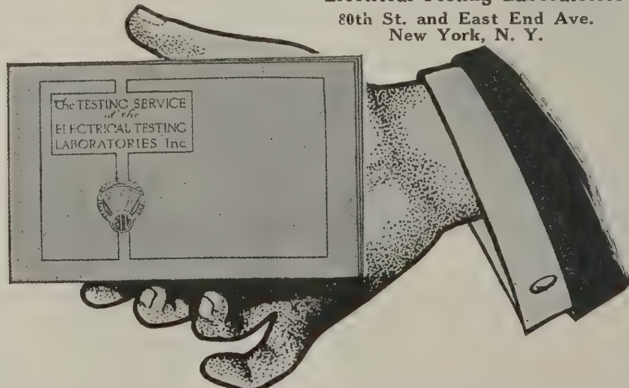
Courtesy of the Illuminating Engineering Society.

The above illustration shows how the problem of adequate illumination has been solved in this large shop. Note the excellent distribution of the light and the shielding effect of the girders which serve to reduce the glare.

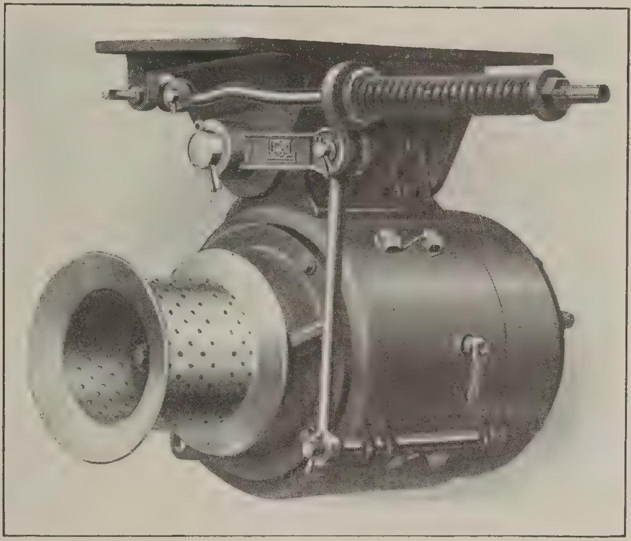
The services of the ELECTRICAL TESTING LABORATORIES should prove of service to you in solving your lighting problems for shops, depots, offices, freight houses, yards, docks, etc.

Send for "Testing Service," a booklet of service to all seeking The Satisfactory Solution of Lighting Problems.

Electrical Testing Laboratories
80th St. and East End Ave.
New York, N. Y.


The TESTING SERVICE of the ELECTRICAL TESTING LABORATORIES Inc

Mount the U-S-L Generator on Car Body or on Truck as desired



THE standard U-S-L Axle Generator may be mounted either on a U-S-L Truck Suspension or, by means of a U-S-L body-hung or so called "under-frame" suspension, directly on the car body.

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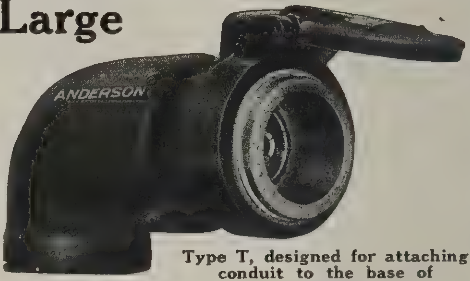
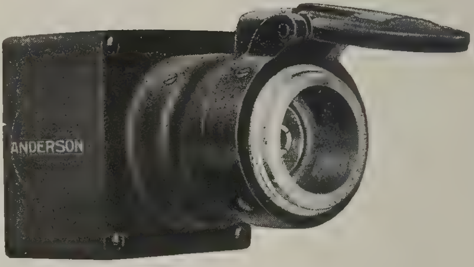


Type T, designed for attaching conduit to the base of mounting.



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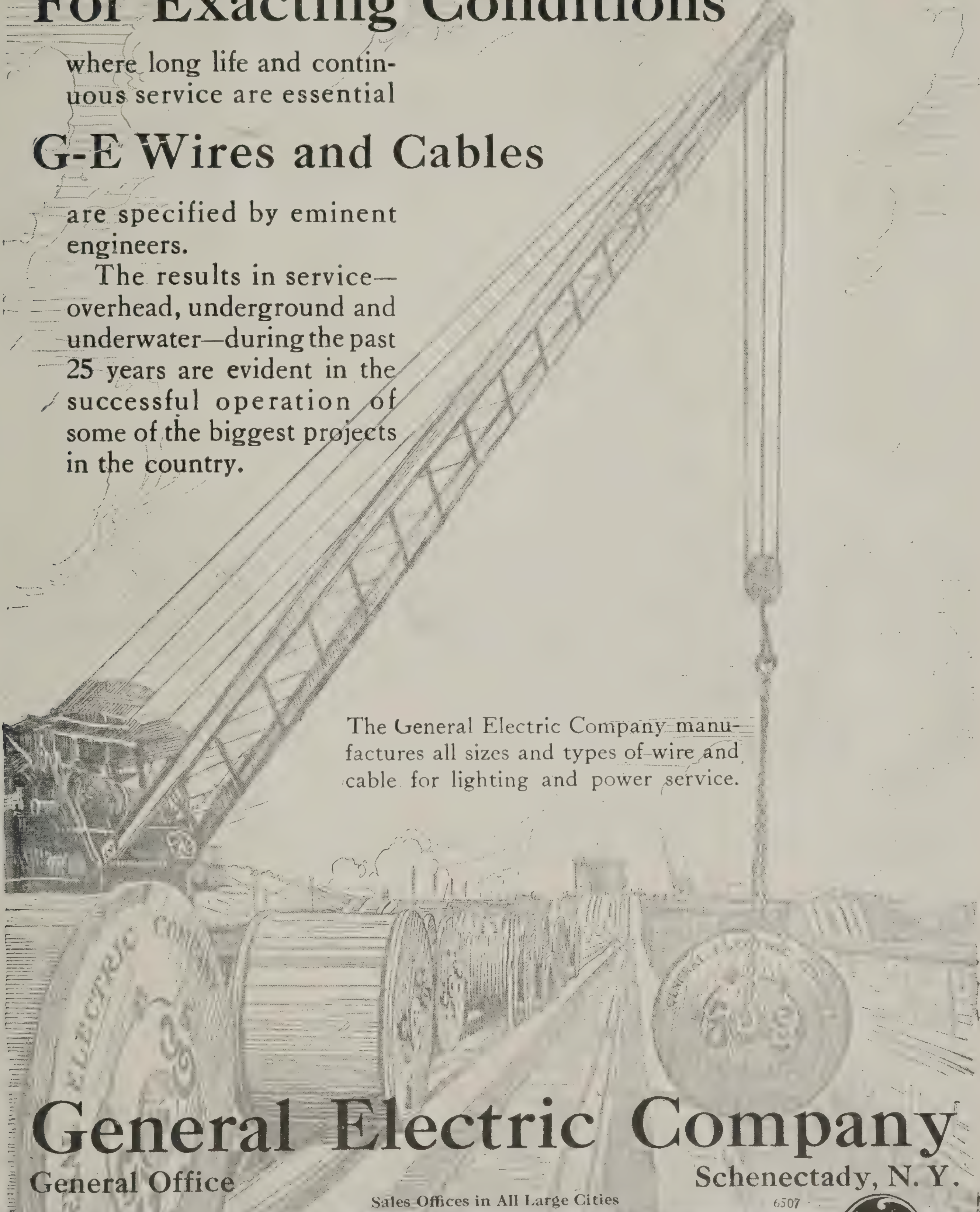

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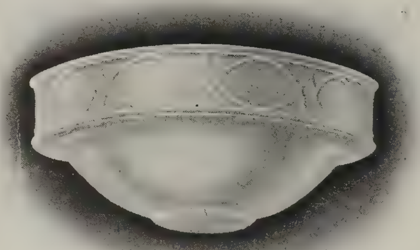

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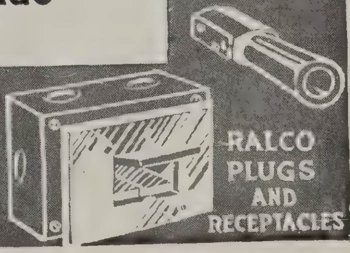

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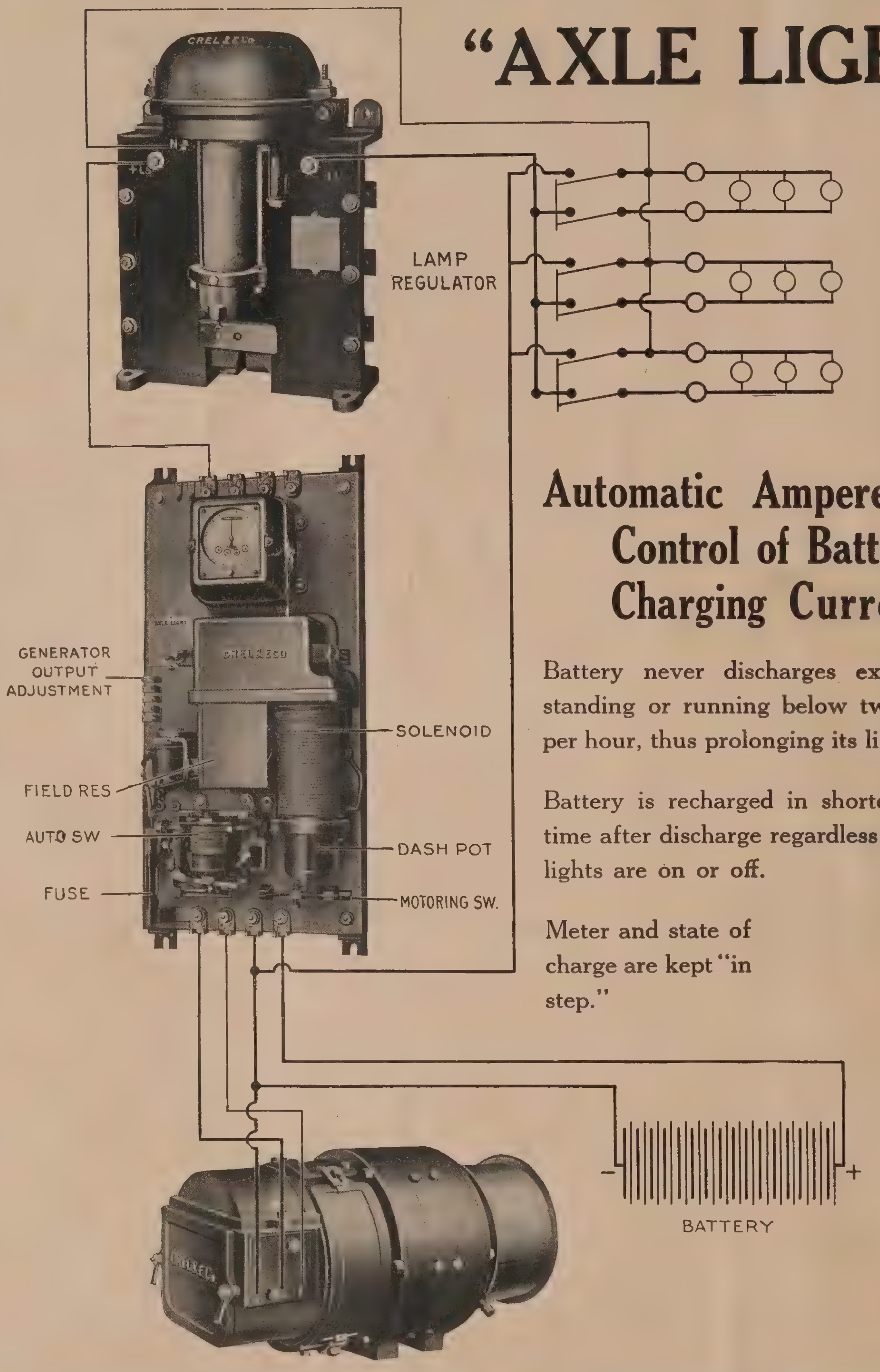

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